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BD 96-04

ADVANCED WASTE MANAGEMENT TECHNOLOGY EVALUATION

Contract NASW - 5005

FINAL REPORT
June 1996

Prepared for:
NASA Headquarters
Washington, DC

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1.0 OVERVIEW, STEAM REFORMING OF SPACECRAFT WASTES

The object of this program was to evaluate the feasibility of gasifying and steam reforming typical spacecraft wastes into simple recyclable inorganics; specifically, to convert complex organic compounds found in these waste products into inorganic molecules, carbon dioxide and water. In order to effectively purify waste products including cellulosic and other organic wastes, urine salts, feces, soap (Igepon™ TC-42) and some plastics, the study investigated the effects of:

- (steam) gasification temperature
- steam reformation temperature
- oxygen addition (up to approximately 10% in steam)
- the benefit of a steam reforming catalyst; and
- catalyst type

The steam gasification and reforming reactions were studied over a sufficiently wide range of operating conditions to identify those conditions, which may offer an attractive alternative to the spacecraft waste problem. Ideally, the steam reforming process will enable the recovery of inorganic residues in a form which is conducive to their recycle into a closed biologic system such as depicted in Figure 1.

The experimental design featured the capability to steam gasify model wastes at temperatures up to 1400° F and reform the evolved volatiles at temperatures up to 1800°F. Both the non-catalytic and catalyzed reforming reactions were studied. The tested reforming catalysts included both ruthenium and nickel/cobalt. In addition, the experimental design permitted the addition of oxygen. With regard to enrichment with oxygen, the steam gasification/reforming reactions were predominantly endothermic. It was found that small additions of oxygen, at least up to the point of overall thermal neutrality ($\leq$ 10% O2 in 90% steam), greatly enhances the gasification rate and suppresses formation of any organic or carbonaceous solid residual from the gasification reaction.

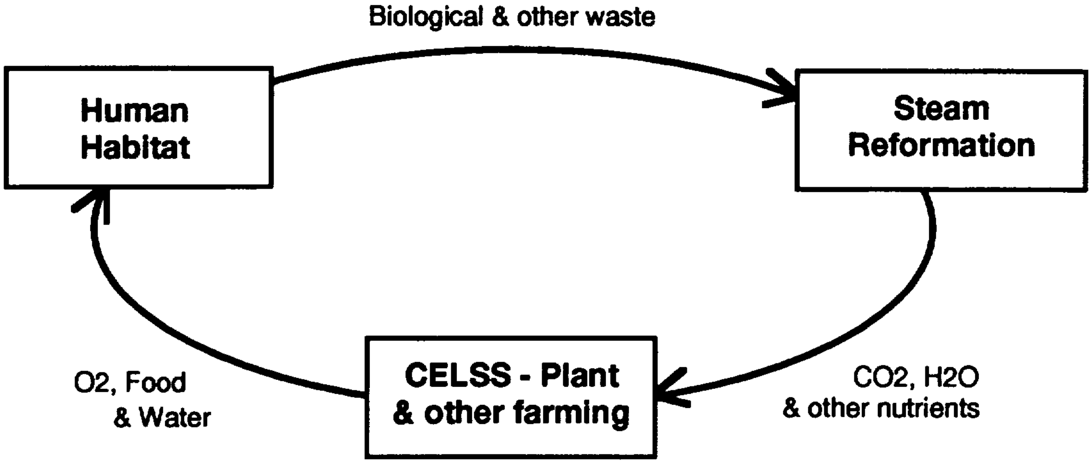

Figure 1 Biological Life Cycle

2.0 SUMMARY

An experimental system for gasifying and reforming spacecraft generated wastes into simple recyclable inorganics was designed, fabricated and studied to obtain reproducible experimental data. The experimental setup included two reactors: (1) a gasifier which operated with a steam purge at temperatures up to 1200-1400°F to effect the conversion of solid, liquid or mixed organic wastes to primarily a gaseous product mix; and (2) a reforming reactor that further refined the gasifier effluent at temperatures up to 1800°F.

The efficacy of steam gasification for processing spacecraft wastes was studied using several pure, reagent grade model compounds. The model compounds included:

(1) cellulose
(2) urea
(3) Igepon™TC-42 (a hygienic soap especially developed for space use)
(4) polyethylene
(5) sucrose
(6) butyric acid; and
(7) methionine (a sulfur containing amino acid found in human feces)

These compounds were tested individually and in combination to simulate typical spacecraft wastes. A sample of wheat straw (made available for testing under this program by the Ames Research Center) was also tested both by itself and as a 25% constituent of a "Referee Mix". These compounds were tested under various conditions of gasification temperature, oxygen enrichment and reformation temperature as shown in Table I. All runs were conducted at an absolute pressure of approximately 105 ± 5 psia. A total of 24 tests were conducted (25 if the continued gasification of a cellulose char in Run #3a is counted as a separate run). One run was conducted with a ruthenium reforming catalyst on γ-alumina substrate and six runs with a nickel/cobalt reforming catalyst as shown in the table.

Table I Steam Reformation of Various Organics

Run	Material	Initial Mass (grams)	Temperatures Gasifier (Deg F)	Temperatures Reformer (Deg F)	Run Duration (hr:min)	Reformer Catalyst	Inlet Oxygen Conc. (per cent)	Inlet Oxygen % of stoichometric	Char Mass (grams)	Comments
I.	**Non-Catalytic Reformations:**									
1	cellulose	5.02	1200	1400	1:04	none	-	-	-	
2	cellulose	5.05	1200	1400	1:45	none	-	-	0.95	
3	cellulose	5.79	700	1400	1:37	none	-	-	1.44	
3a	cellulose char	1.44	1200	1200	1:35	none	-	-	0.73	
4	cellulose	5.22	1200	1400	1:32	none	9.0 %	**280 %**	0.00	
5	cellulose	5.81	1400	1400	1:08	none	3.2 %	48.7 %	0.66	
6	urea	10.45	1400	1400	1:41	none	2.7 %	71.3 %	0.00	
7	urea	9.99	1400	1600	0:14	none	1.1 %	4.2 %	0.00	Aborted run; system plugged @ t+24 min wi gasifier = 165°C, max reformer temp 643°C.
8	Igepon TC-42	6.54	1400	1400	1:08	none	3.2 %	**103 %**	-(1)	
9	cellulose (2)	3.58	1400	1400	1:08	none	3.3 %	**153 %**	0.31	residual 0.31 g. of lt gray, pumice-like ash
10	Igepon TC-42	8.66	1400	1600	1:17	none	3.9 %	**117 %**	-(1)	
11	Igepon TC-42	8.45	1400	1600	1:28	none	3.2 %	**101 %**	-(1,3)	Reformer wi 1 hr. preheat (to 1600°C). Gasifier temp, T2 = 151°C at t+00 min.
12	polyethylene	6.81	1400	1600	0:52	none	2.9 %	13.7 %	-(1)	New heater schedule: gasifier heat delayed to t+24 min. Problems wi system plugging.
13	sucrose	6.60	1400	1400	0:52	none	-	-	0.14	Steam only, recovered char 0.14 g. Severe plugging begin @ t+51 min.
14	cellulose	6.56	1400	1600	0:49	none	-	-	3.03	
15	cellulose char	3.03	1400	1600	1:31	none	-	-	1.18	3 pt. temp recorder installed.
16	butyric acid	5.37	1400	1600	0:54	none	2.1 %	22.7 %	-(1)	
17	methionine	4.76	1400	1600	0:59	none	0.0/2.1%	23.5 %	-(1)	

Table I Steam Reformation of Various Organics (Cont)

Run	Material	Initial Mass (grams)	Temperatures		Run Duration (hr:min)	Reformer Catalyst	Inlet Oxygen		Char Mass (grams)	Comments
			Gasifier (Deg F)	Reformer (Deg F)			Conc. (per cent)	% of stoi-chiometric		
II.	Catalyzed Reformations:									
18	polyethylene	6.14	1400	1600	2:10	ruthenium	7.4 %	12.5 %	< 0.1[4]	Severe reactor plugging w gas loss @ relief valve. Could not maintain flow rates. Alumina catalyst cemented, catalyst replaced.
19	polyethylene	6.52	1400	1600	1:23	nickel/cobalt	3.0 %	22.0 %	-[1]	
20	methionine	6.10	1400	1600	1:05	nickel/cobalt	3.7 %	45.5 %	-[1]	Gasifier effluent ex. strong odor, absent in reformed effluent.
21	urea	6.92	1400	1600	2:48	nickel/cobalt	3.1 %	176 %	-[1,4]	Could not maintain flows. Severe plugging reformer catalyst bed.
22	Igepon TC-42	7.04	1400	1600	1:42	nickel/cobalt	11.2 %	117 %	-[1,4]	Severe plugging - traced to accumulation of catalyst fines @ reformer exhaust port.
23	Referee Mix[5]	10.11	1400	1600	0:31	nickel/cobalt	3.5 %	48.4 %	< 0.1	
24	Referee Mix[5]	10.22	1400	1600	1:07	nickel/cobalt	3.5 %	72.4 %	< 0.1	

[1] No organic or carbonaceous residue observed - trace inorganic salts residual.

[2] Sample of wheat straw received from NASA Ames, 12-4-95.

[3] Same as Run #10 except that reformer brought up to 1600°F reaction temperature prior to initiation of gasification heat and water & oxygen flow.

[4] Severe plugging prevented maintenance of nominal flow rates.

[5] Paste comprised of: 10 wt % polyethylene; 15% urea; 50% cellulose; 20% Igepon TC-42; and 5% methionine (dry mass) with 39% added water.

The data indicated that even trace oxygen concentrations (approx. 3 % in steam) were quite successful in suppressing the formation of a carbonaceous residue. This is clearly beneficial for a waste processing system. Also, at a temperature of 1600°F the nickel/ cobalt reforming catalyst was shown to effect the nearly complete destruction of the effluent stream's organic content. In this regard, the power of the nickel-cobalt reforming catalyst is perhaps most clearly shown by the data from the Referee Mix in Runs #23-24 and from comparison of the catalytic vs. noncatalytic results obtained from the steam reformation of urea and methionine. Ammonia and methane are commonly regarded as being among the most stable organic molecules, especially in a net reducing environment. In this investigation, methane was detected by gas chromatographic analysis of the gasifier and/or reformer effluents downstream of the cold trap and filter elements.

Runs #23-24 provided several significant observations; these are summarized in Table II.

Table II Catalytic reduction of Methane in Gasifier Effluent Stream
(Results obtained with Nickel/Cobalt catalyst @ 1600°F)

Elapsed Time (minutes)	Crucible Temp (Deg C)	Mole % CH4 in Effluent Stream	
		Gasifier	Reformer
Run #23:			
48	160-180	0.1 %	
56	350-550		0.0 %
61.5	600-630	18.7	
69.6	700		0.8
75	730	8.4	
Run #24			
44	160	0.1 %	
50	200-250		0.0 %
55.5	500-600	17.9	
61	650		1.4
69	700	14.0	
78	740		0.1
11.3	740	0.0	

In Table II the methane (CH_4) concentration of the gasifier effluent before and after passing through the nickel-cobalt reformer catalyst bed can be followed as a function of time. As will be discussed in connection with the system schematics, the gasifier effluent can be immediately sampled. In this case it never passes through the reformer. However, it can be first routed through the reformer reactor, depending upon the position of the three way valve, R_5, shown in the schematic of Figure 2. Hence, the composition analyses, before- and after-reformation cannot be contemporaneous. Nevertheless, it is clear from switching back and forth between: (1) the composition of the gasifier effluent (prior to catalytic reformation) and; (2) the composition of the gas effluent from the reformer reactor as shown in the Table II above, that at 1600°F the nickel-cobalt reformer catalyst converts somewhere between 90 and 99% of the methane initially present (presumably) to inorganic residues such as CO and CO_2. That is, the conversion to CO and CO_2 is logical, but this conversion cannot be proven from the data on hand - the data on hand proves only that methane has disappeared. In this regard it is also significant that the same catalyst was used for all six runs from Runs #19 to Run #24. The fact that it retained the high activity was demonstrated by the results shown in Tabale II after: exposure to the effluent from polyethylene in Run #19; exposure to both sulfur and nitrogen with the gasification of methionine in Run #20; a further exposure to nitrogen with the gasification of urea in Run #21; and a continued exposure to still more sulfur and nitrogen with the steam reformation of Igepon™ TC-42 and the Referee Mix in Runs #22-24. This is exemplary of a commercially viable useful life in the present applications.

Results suggesting a comparable level of activity for the catalytic oxidation of organic nitrogen and/or ammonia are indicated by comparison of the data from Runs #6, 7 and #17 - uncatalyzed reformation of urea (Runs #6-7) and methionine (Run #17) and with the data for the catalyzed reformation of urea and methionine in Runs #20-21. In the absence of an amine group (- NH_2) or an organic- (or inorganic-) acid content, the cold trap condensate was typically acidic, pH = 3-4. This is not unexpected, since with a cold trap temperature of 0°C a substantial fraction of any carbon dioxide produced will be adsorbed and impart the indicated acidity. However, a mildly basic (double) amine with an appreciable vapor pressure, such as urea, might be expected to produce a basic condensate. Urea could be distilled into the trap or it could dissociate to produce ammonia or a methyl amine. Either would account for the observed basic pH. This was in fact observed in the raw gasifier effluent from Runs #6 and #21 as shown in the table below. Interestingly, homogeneous (non-catalytic) reformation at 1600°F - in the case of the reformer effluents from Runs #6 and 7 - appeared to produce an even more basic condensate. This could result from the breaking down of an organic amine group (- NH_2) to ammonia. However, with the nickel-cobalt catalyst in Run #21, the reformer effluent was (relatively) strongly acidic. Since urea, $(NH_2)_2 CO$, does not feature any other radical groups whose oxidation (or reduction) could explain the observed acidity, the strong acidity shown for the reformed effluent in Run #21 has likely to have come from the catalytic oxidation of ammonia (or an organic amine group) to NO_2, which, in turn, would have dissolved and generated a nitric acidity in the cold trap condensate. This interpretation is also consistent with the pH difference shown in Table III between the catalytic- and non-catalytic- reformed effluents from other runs, notably the gasification of methionine.

Table III Effect of Nickel/Cobalt Catalyst in Steam Reformation of Materials with Organic Nitrogen Groups

Material	pH of Condensate recovered from	
	Gasifier Trap	Reformer Trap
Urea:		
Run #6	9.0	11 (w/o catalyst)
Run #7	-	11.5 (w/o catalyst)
Run #21	10.5	2
Methionine:		
Run #17	-	8.0 (w/o catalyst)
Run #20	8.0	2

A more detailed discussion of these and other experimental data is presented in the following pages. It is strongly recommended that further study of steam reformation as a candidate waste treatment process be conducted.

3.0 EXPERIMENTAL SYSTEM

Before discussing specifics of the test program it is desirable to consider certain features of the test apparatus depicted in the schematics of Figures 2 and 3. Figure 2 is a schematic of the original test configuration as designed. It was discussed in the first quaraterly report. As conceived, a steam flow of 0.4 to 5.0 grams/min - approximately 500-6000 cc/min (STP) - is controlled by the rate at which water is metered to the tubular steam boiler/gasifier. It was intended that a uniform water inlet flow ranging from 0.4 to 5.0 cm^3/min would be obtained from a positive displacement pump (Cole Parmer Model #H-74400-00 or equivalent) where any pulsations were eliminated by the combination of a surge volume, V, and needle valve, R_1 , elements shown in the figure.

However, in the configuration of Figure 2, water contact with the cushioning gas blanket in the surge volume, V, used to attenuate pump pulsations, occured at the highest system pressure, and therefore there was a natural tendency for the gas from the surge blanket at V to dissolve in the inlet water stream and precipitate out upon the rotameter surfaces and float at the lower pressure condition attending pressure letdown at R_1. For that reason a membrane barrier was incorporated between gas and liquid phases at V. However, a Model A-60-3 metering pump from Eldex Laboratories, Inc., Napa, CA with a capacity of 0-10 cc/min became available to the program and this element was combined with a 250 cc burette as shown in the schematic of Figure 3. This configuration provided a superior water delivery system and the burette afforded a near absolute determination of the amount of water which had passed through the system.

The plumbing into the gas chromatograph (HP #5880A) was also simplified as can be seen by comparing Figures 2 and 3. In practice, an on line gas chromatograph run required approximately 30 minutes. To enable a more frequent determination of the composition of the gas streams effluent from the gasifier and reform reactors, gas samples were collected in Teflon bags between chromatograph samples for subsequent gas chromatographic analysis. These determinations are designated as "Bag" in the data for individual runs compiled and presented in the Appendix to this report, as opposed to "GC" denoting an on-line chromatographic analysis. The difference can be important because, typically, there was some diffusional exchange between the atmosphere and the reformer effluent gases bagged from a run. Diffusioned exchange does not exist for the on-line gas chromatographic determinations.

Referring again to the schematic of either Figure 2 or 3, parallel gaseous feed paths controlled by needle valves R_2 and R_3 were used to meter oxygen and helium into the system (nitrogen was used instead of helium for Run #1). The addition of an inert gas was desirable both to stabilize the condensing flow at low gasification temperatures - where the concentration of non-condensibles was insufficient to preclude the encounter of a flow instability at the point of steam condensation - and for safety. Typically, the inert gas flow amounted to 120-150 scc/min, whereas the oxygen flow was on the order of 50 scc/min. Thus, even after (essentially) all unreacted water was condensed out from the gasifier or reformer effluent streams at the cold traps, the oxygen concentration in the stream fed to the gas chromatograph (or bagged for subsequent chromatographic analysis) never exceeded approximately 30%.[1]

Downstream of the flow metering elements, the inlet water and gas streams combine and and flow into a steam boiler/superheater en route to the Gasifier as shown in Figure 3. Both the boiler/superheater and gasifier elements were enclosed within a single 4.5 KW tube furnace. The tube furnace was manufactured by Applied Test Systems, Model #3210, and featured an internal heated volume 3.75 inches in diameter x 24 inches long. The furnace can be operated at any temperature up to a maximum of 1100°C (2012°F). In comparison with the 4.5 KW capacity of the furnace, the theoretical heat required to boil 0.4-5.0 cm^3/min water and superheat the steam to 1200°F is only 27-335 watts; but the larger heated internal volume was desirable to accomodate both boiler and gasification elements and offset system heat

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[1] the cold traps were fabricated from one-inch stainless steel tubing and were maintained at 0°C by a Cole Parmer refrigeration element (Polystat Model #12101-10). At this temperature the water content of the effluent at equilibrium would amount to only 0.07% (at 105 psia).

leaks. The maximum gasification temperature tested was 1400°F. The thermal energy required to boil and superheat the inlet water stream to 1400°F is depicted as Q_1 in the schematic of Figure 3 and the heat required to maintain a constant gasification temperature as Q_2. As shown in Figure 3, the effluent from the gasification reactor can be analyzed directly or the flow can be further processed by the reforming reactor depending upon the flow path opened by the setting of downstream 3-way valve, R_5. The flow configuration shown with the 3-way valve, R_5, and filtration elements downstream of the condenser protects the gas sampling valve, R_8 (leading to on-line gas chromatagraphic chemical analysis), from solid or tar-like gasification residues which might otherwise escape from the steam reforming system. An on-line gas chromatographic unit, Hewlett Packard Model 5880A with either thermal conductivity or Flame Ionization Detection, was used to analyze the gaseous effluent from the reactors. A single analysis of the condensed liquids from Run #1 supplemented the information gained from chromatographic analysis of the non-condensible fraction of the gas streams effluent from the cold trap and filter elements.

More typically, the gasifier effluent which includes the products of the primary gasification reaction, flowed into the second (reforming) reactor. The reforming reaction, which was typically conducted at 1600°F, effected a further breakdown of the primary gasification reaction products to predominantly carbon monoxide, carbon dioxide and hydrogen. A single test was run with a ruthenium catalyst (20% Ru on a high surface area γ-alumina (Run #18), but this test was unsuccessful because the γ-alumina substrate cemented together under the high water partial pressure and the run had to be aborted. A Nickel/Cobalt catalyst on 1/8" cylindrical α-alumina pellets (Harshaw Ni-1601 T 1/8 E59-1-10-2 with 3% each of nickel, cobalt and iron) was used for Runs #19-24. This catalyst showed excellent reactivity and produced the reductions of methane and ammonia discussed earlier in the SUMMARY section of this report.

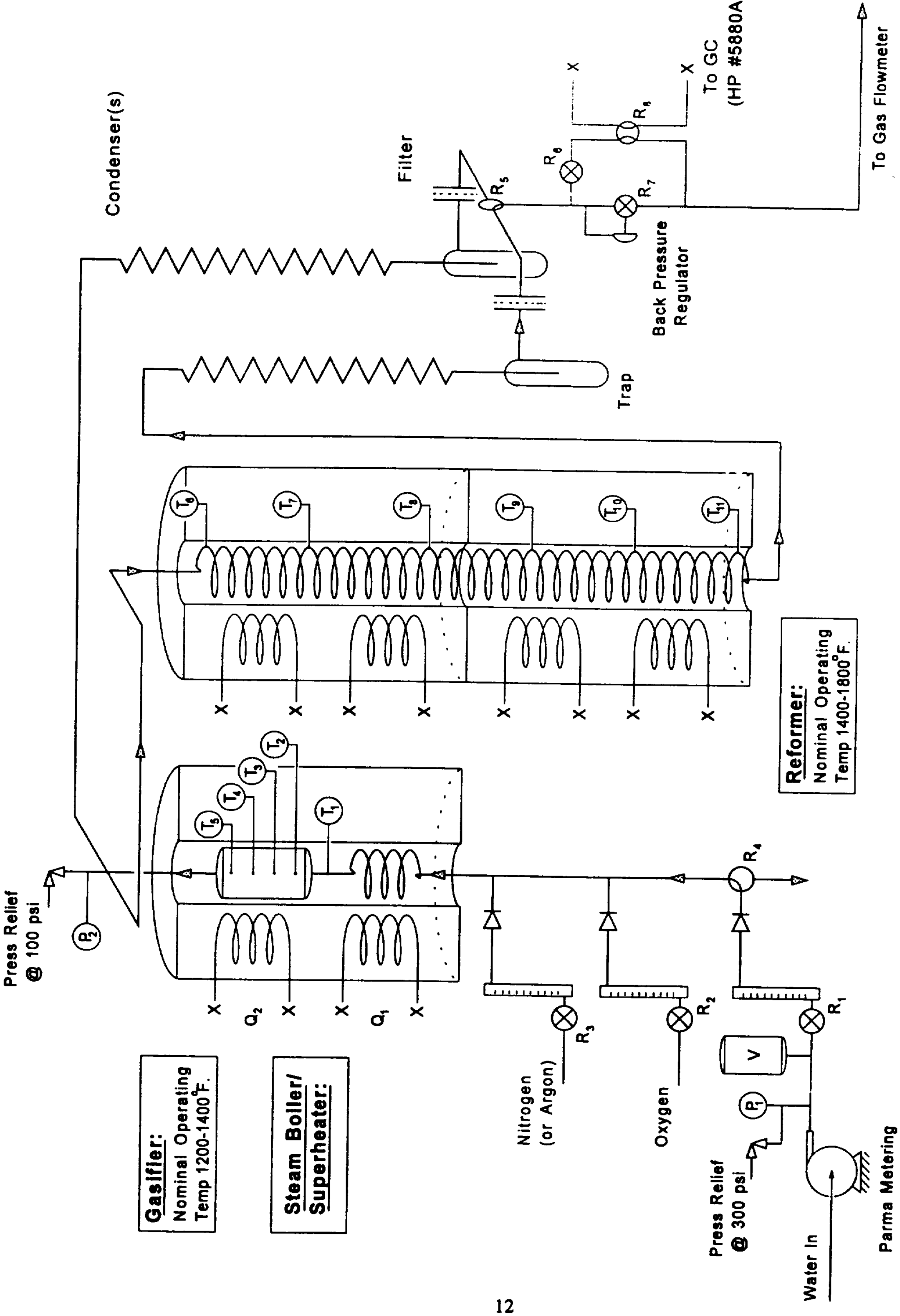

Figure 2 Schematic of Steam Gasification/Reforming Test Configuration

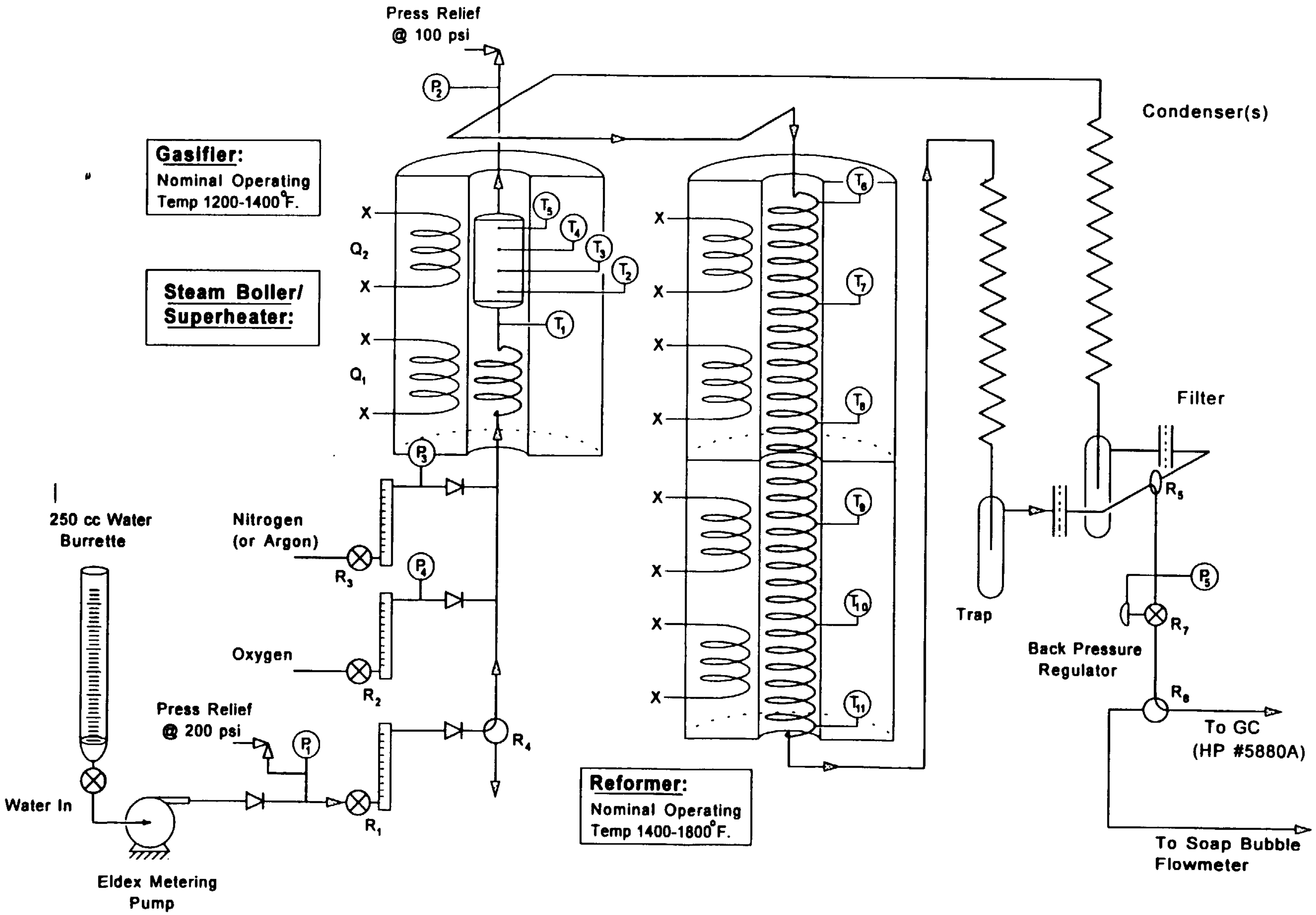

Figure 3 Schematic of Steam Gasification/Reforming Test Configuration

3.1 Reactor Design

3.1.1 Gasification Reactor

A drawing of the gasification reactor fabricated for this work is presented in Figure 4 and is shown approximately to scale in the figure. It features an internal volume of approximately 90 cc. To enable extended operation at temperatures up to 1400°F, it was fabricated from Inconel #625. The tested model waste reactants were loaded into the 40 ml Gooch crucible (available from Fisher Scientific) such that the gas (steam) flow was vertically downward, from top to bottom, through a packed reactant bed and out through a multiplicity of 0.7 mm perforations at the bottom of the Gooch crucible. Liquid organics such as Igepon™ TC-42 could be adsorbed upon a solid carrier such as cellulose which is reactive, or upon a low surface area γ-alumina, which is not active, when the reactor is loaded. Runs with an organic carrier such as cellulose might best model a real gasification scenario[2], whereas a structurally rigid, inert support of uniform mesh size, such as γ-alumina, is probably a superior experimental vehicle, at least in principle. This allows reconstruction of an advancing gasification front from the recorded temperature versus time history of the thermocouples.

To record reaction temperatures during gasification four Inconel 600 sheathed Type K (chromel/ alumel) thermocouples were installed through the fittings shown at the top of the figure. The penetration was staggered - at approximately 0.250" intervals - to monitor the temperature of the charge at different levels during gasification. A photograph of the disassembled gasification reactor in Figure 5 shows the staggered penetration of the thermocouples in relation to the Gooch crucible. The seal ring shown in the picture, even with a 0.001 inch silver plating did not perform well after the initial run and was eventually replaced with a soft copper ring machined out of bar stock and subsequently annealed at 750°C. The deformable copper ring consistently provided an excellent seal and is recommended for use in future work. At gasification conditions of 1400°F and 105 psia the nominal gas flows amounted to:

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[2] This experimental condition was met in Runs #23-24 where a Referee Mix incorporating six different model waste materials was tested.

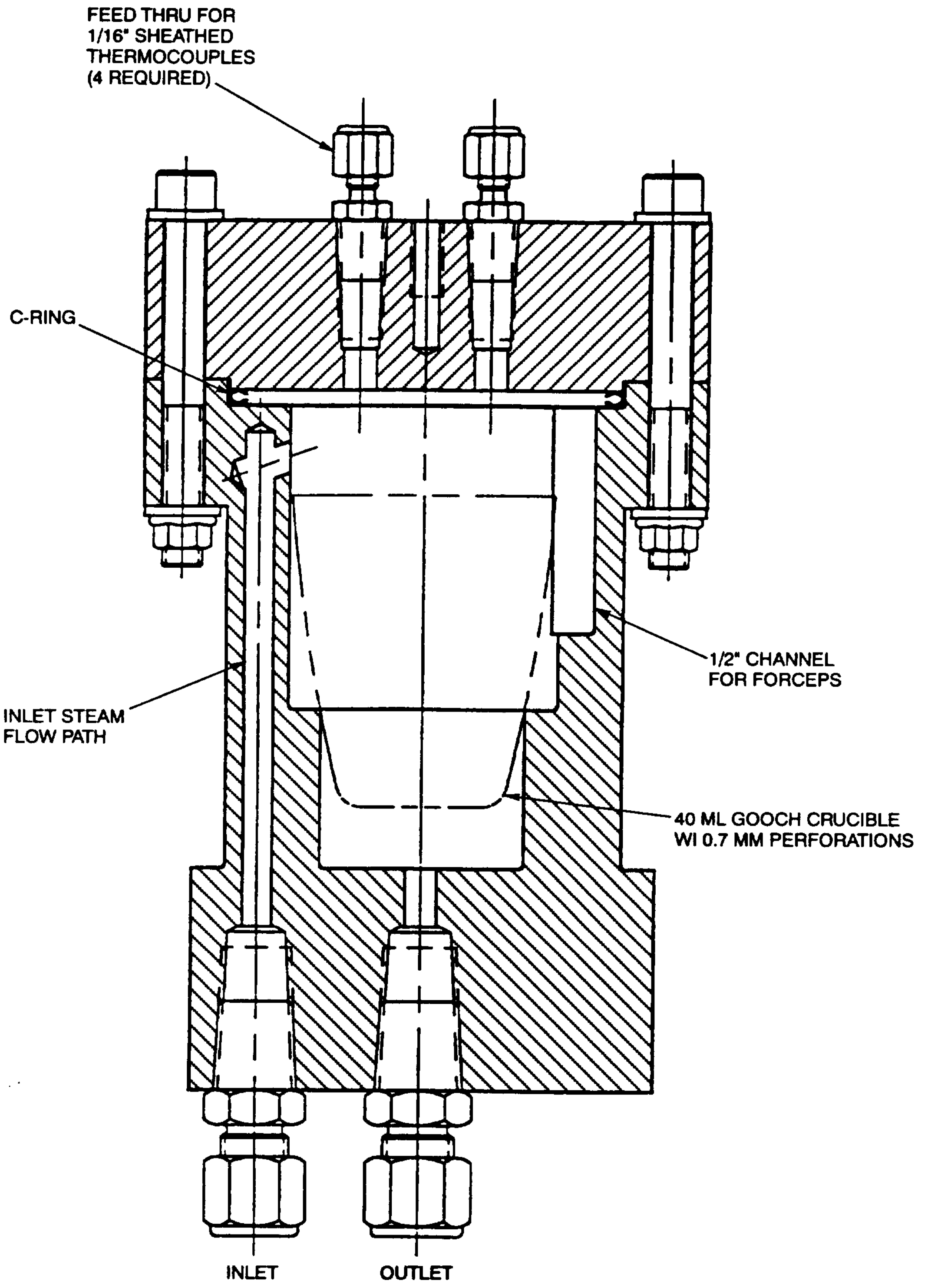

Figure 4 Gasification Reactor

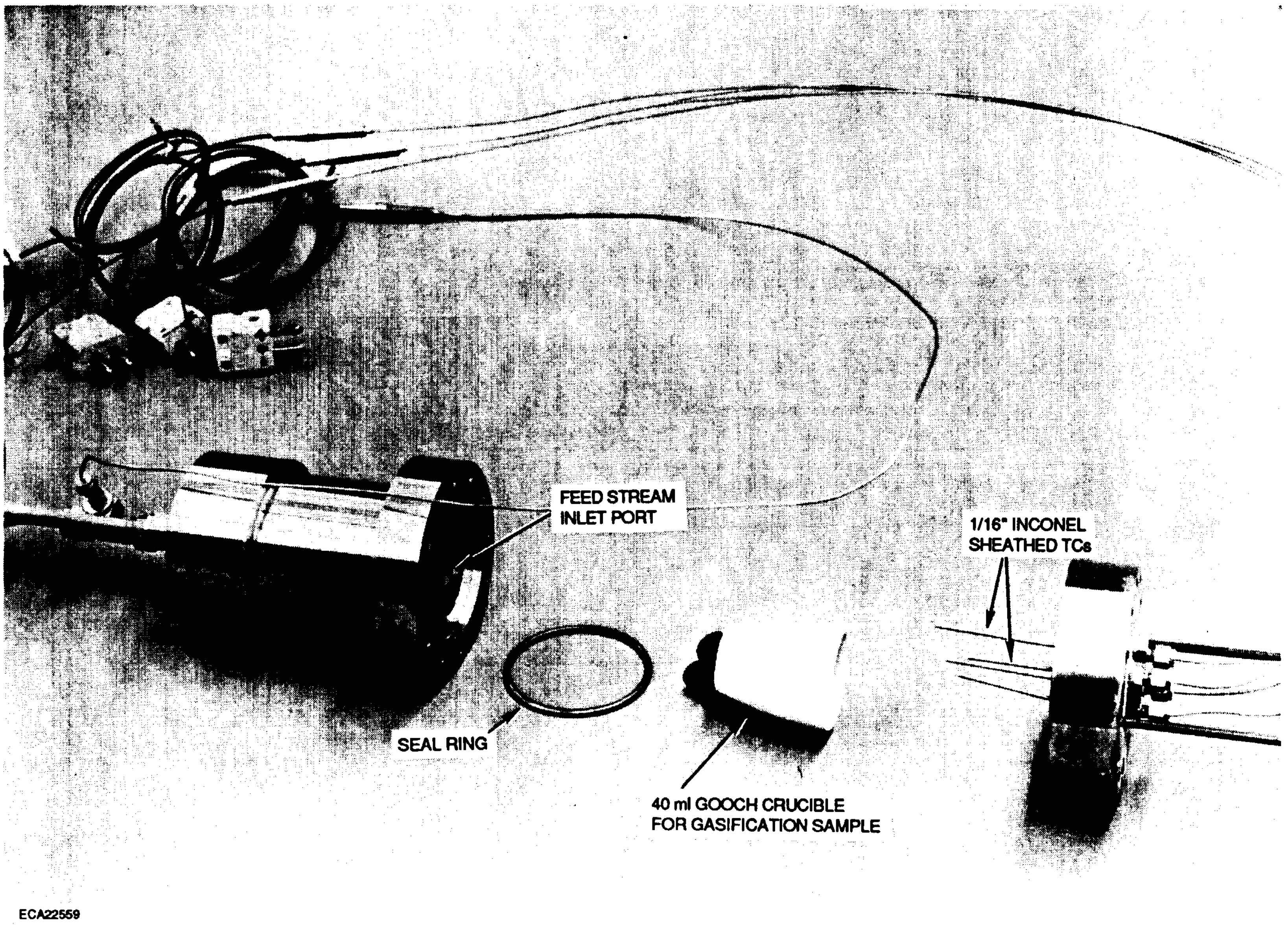

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Figure 5 Disassembled Components of the Reactor

steam	1.15 g	or	1560	scc/min
helium			130	
oxygen			60	
Total	----->		1750	scc/min

The reactor residence time was approximately 0.1 minutes.

3.1.2 Reforming Reactor

The reforming reactor fabricated for this project is shown in Figure 6. To facilitate temperature control - in the case of the homogeneous (non-catalytic) reaction - and better accomomdate the containment of up to 150 psi at the maximum operating temperature, it was fabricated from (approximately) a 50 ft. length of half-inch O.D. x .049 inch wall Inconel 625 tubing. The tubing was formed into a 3.25 inch O.D. x 40 inch long coil with approximately a 0.75 inch pitch between turns. Three 0.25" tubes shown supported the coils from sagging and housed six 1/16" Inconel #600 sheathed thermocouples which monitored reactor temperature. The reforming reactor was housed within two coaxial Applied Test Systems, Model #3210 tube furnaces placed end-to-end in a vertical orientation as was depicted by the schematics of Figures 2 and 3 and in the photograph of Figure 7. The Steam Boiler / Superheater coil called out in Figures 2 and 3 can also be sen in the photograph of Figure 7. In all cases gas flow was vertically downward through the reactor. The internal volume of the reforming reactor was 700 cm^3. At operating conditions of 1600°F and 105 psia, the nominal residence time was 0.7 min.

With a wall thickness of approximately 10% of tube diameter, the reforming reactor configuration shown in Figure 6 is near optimum for extended operation at or close to the temperature limit of the reactor material used. Also, since heat transfer to a slow moving, transparent gas is at best inefficient, the extended aspect ratio ensured that the gas temperature would come arbitrarily close to the temperature of the reactor walls within a relatively inconsequential fraction of the total reaction volume. However, in the case of catalytic reformation, a pressure drop of at least 3 psia (with a 10 mesh packed catalyst bed) was calculated. And of course, the design is much less resistant to plugging where the possibility for deposition of solids exist (i.e. solid carbon or condensed high molecular weight organics at the cooler exhaust end of the reactor). Since (after the fact) it has become clear that a reforming catalyst is desirable, the design shown in Figure 6 may be somewhat improved, and should be replaced with a packed bed of a more conventional design in any future work.

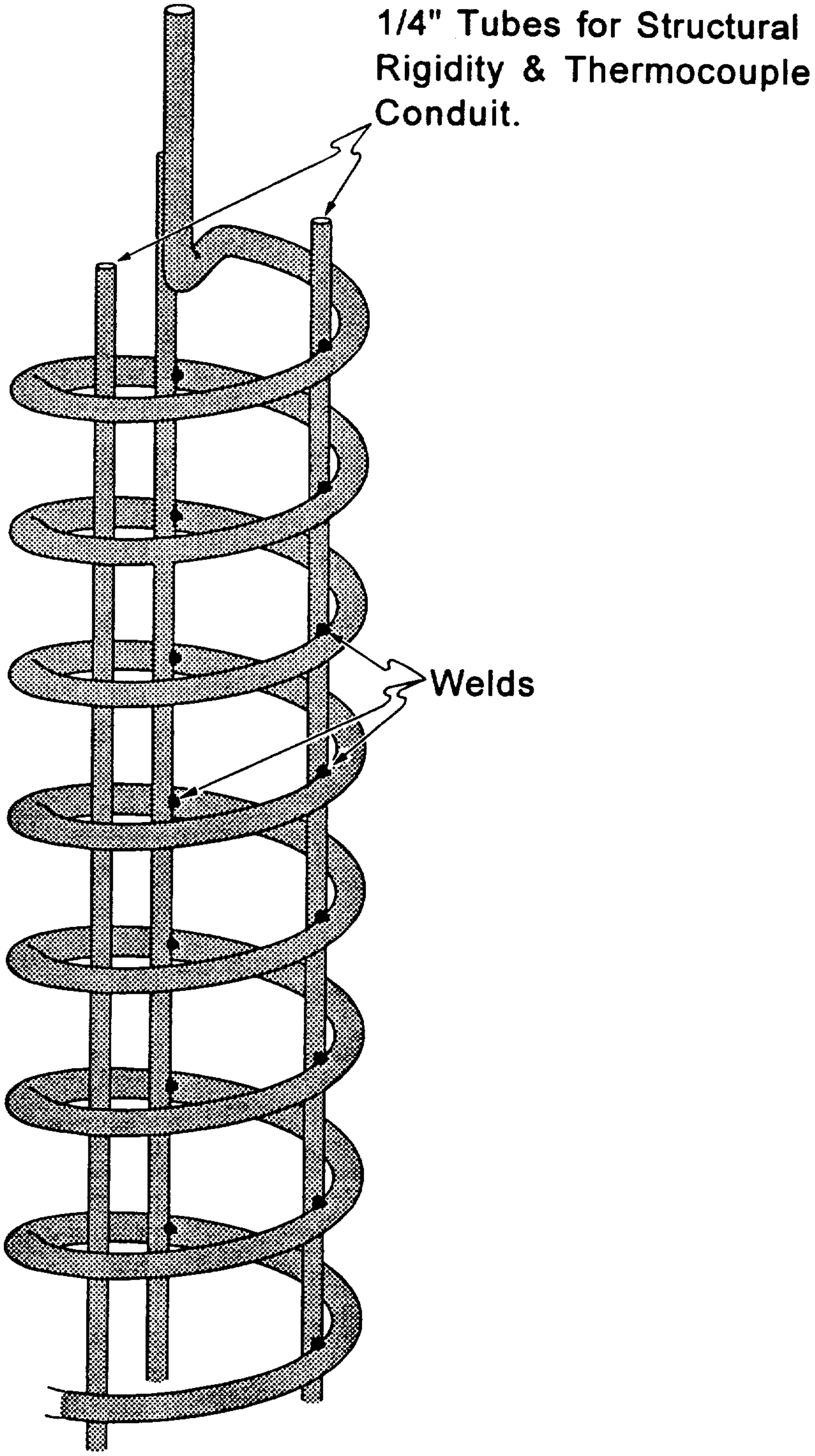

Figure 6 Reforming Reactor: 50 Ft of 1/2" Inconel #625 Tubing (Internal Volume: 700)

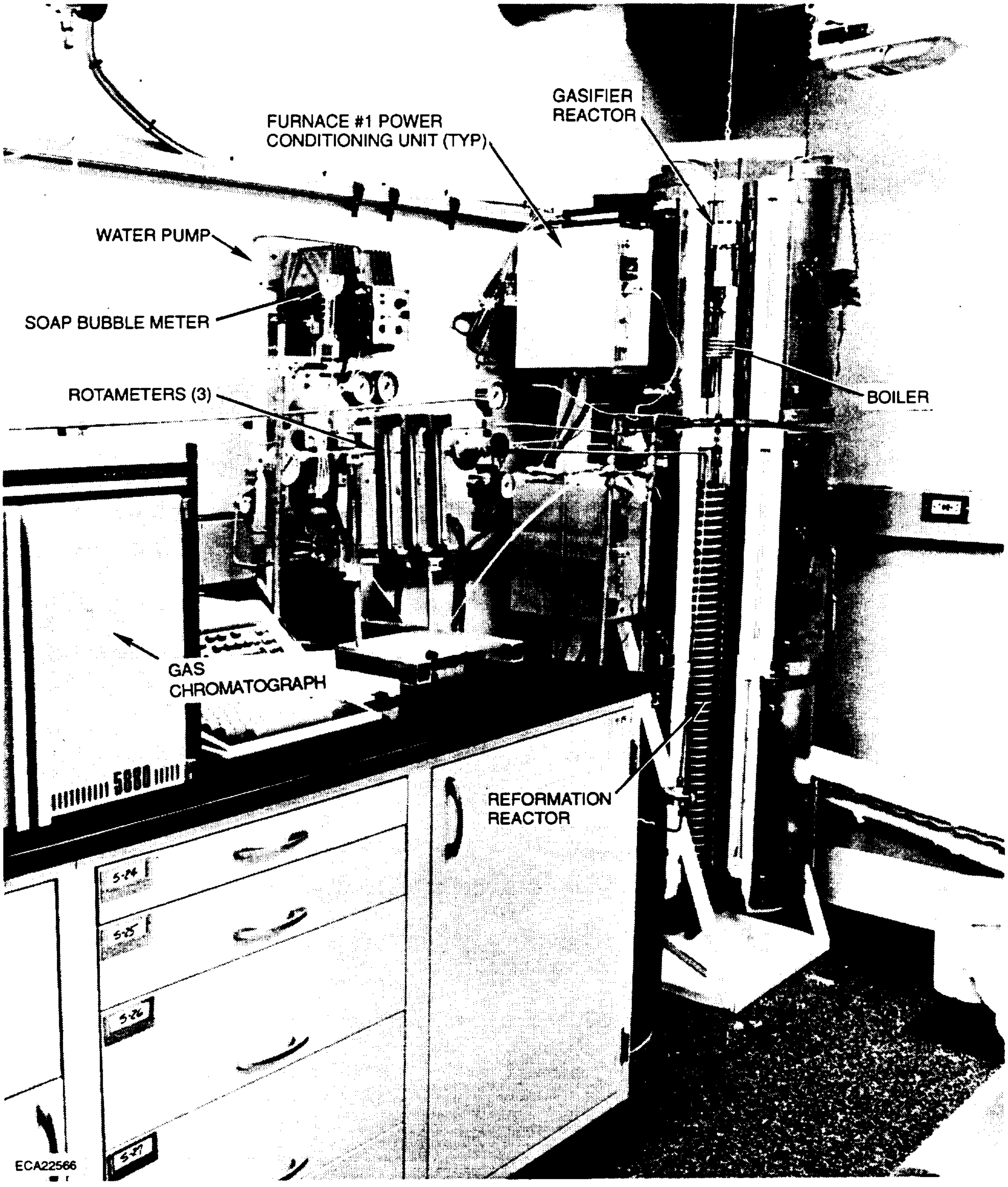

Figure 7 Photo of Test Apparatus

3.2 Heating Rates

As the experimental procedures became better developed with use, the heating rates used were also somewhat altered between the earlier and later test runs. Beginning with Run #7 - Urea, it appeared that urea had simply distilled into (condensed) and ultimately plugged the reforming reactor which still had not come up to a sufficient temperature to cause substantial decomposition of the urea. This condition made it clear that it was preferrable if the reformer could be preheated to its steady state temperature (nominally 1400-1600°F) before gasification was initiated. It was not completely practical to achieve this goal, because with the preheating coil (Steam Boiler/Superheater' in Figures 2, 3, 7), and the gasifier reactors within the tube furnace immediately above the reformer tube furnaces, the gasifier gradually came up to a waste volatilization temperature (150-200°C depending upon the model waste material tested) even when the No. 1 (Top) furnace was not turned on. However, without the top furnace turned on it took the gasifier approximately twice as long to heat up and this allowed the reformer to heat up to 750-800°C before there was any appreciable flow of volatiles from the gasification reactor. The difference in heat-up rates between the two approaches is shown in Figure 8.

3.2.1 Gasifier Reactor Heat-Up Rate

In Figure 8 the thermal response of the gasifier charge under various conditions of experimental influence is shown. In the first three, where all furnaces were turned on simultaneously, the effect of differences in model compound type are shown. The last curve from Run #22 illustrates the effect of delaying activation of the No. 1 furnace for 31 minutes (the reformer furnaces No. 2-3 were still turned on together at t+00 min). Since the reformer reactor required approximately 30 minutes to approach its steady state (set point) temperature, it can be seen that the strategy of delaying activation of the No. 1 heater was reasonably successful.

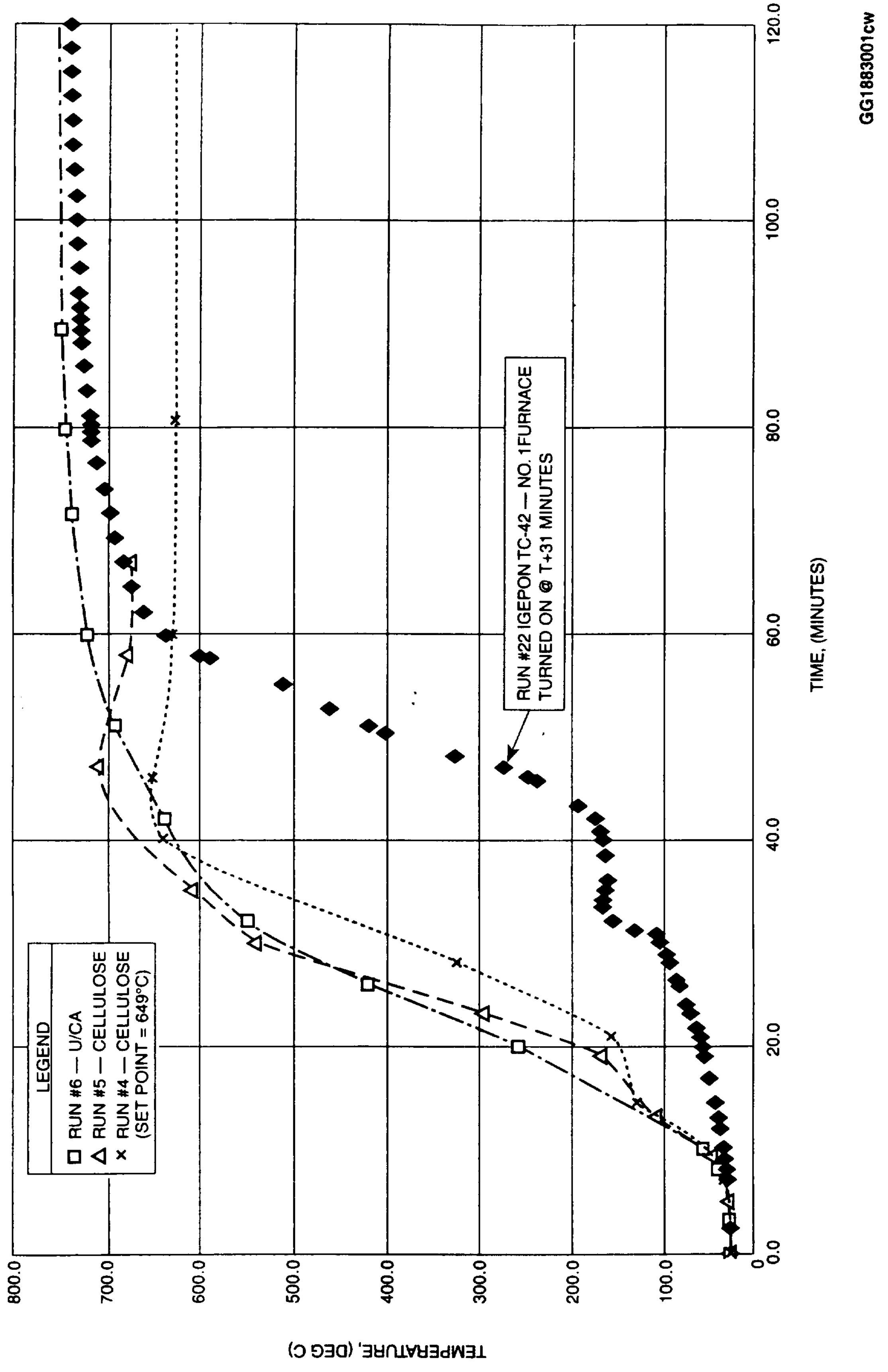

Figure 8 Heat-Up of Gasifier Element

Figure 8 also depicts several of the transient phenomena typically observed during the experimentation. In Runs #5-6 all furnaces were activated at t+00 minutes and water flow was started at approximately t+10 minutes. There is a slight endotherm at 160°C which is more significant in the case of cellulose (Run #5) than it is with urea (Run #6). Since urea melts at 135°C and the endotherm attending the heat-up of cellulose is much more substantial (i.e. large compared with the heat of fusion of urea), it appears significant that the pyrolysis reaction:

$$[C_6(HOH)_5]_x \quad {-}{-}{-}{-}{>} \quad C_{6x} + 5x\ H_2O$$

which (because it involves the breaking of chemical bonds, requires more energy than the melting of urea) is occurring at or about 160°C in the figure. The still greater endotherm attending the gasification of cellulose in Run #4 is probably not significant since in this case the water flow was not started until t+24 min. Thus the discrepancy between runs appears to be significant of the fact that the Steam Boiler / Superheater element was doing its job and the earlier addition of superheated steam in Runs #5-6 effected a more rapid heat-up of the gasifier charge.

The thermal response in Run #22 tends to confirm this interpretation. Furnace No. 1 was not turned on until t+31 minutes and water flow was not initiated until t+32.5 minutes. Since an immediate input of a substantial quantity of No. 1 furnace heat is inconsistent with the rest of the data shown in the figure, it is apparent that the sudden increase in heating rate at (approximately) t+32.5 minutes must come from the condensation of superheated steam. This is also consistent with 170°C boiling point of water at 105 psia. Then after some steam condensation to bring the Igepon™ TC-42 charge rapidly up to approximately 170°C, some additional time is required to boil off this water along with the (approximately) 75% water content of the original charge.

3.2.2 Reformer Reactor Heat-Up Rate

Examples of the thermal response of the reformer reactor pictured in Figures 6-7 are shown in Figures 9-10 for Runs #4 and #22 respectively. In Run #4 (cellulose) the set point temperature was 1400°F whereas in Run #22 (Igepon™ TC-42) the set point temperature was 1600°F. As shown in Figures 6 and 7, the reformer was comprised of a 50 foot coil of 0.500" Inconel 625 tubing. The coil was approximately 42 inches long x 3.25 in. in diameter. It was positioned within two tube furnaces placed one on top of the other as was illustrated in Figures 2 and 3. Its temperature was monitored by six thermocouples spaced symmetrically from top to bottom as follows:

TC #6 - 3.5 inches from top of coil
TC #7 - 10.5 " " " " "
TC #8 - 17.5 " " " " "
TC #9 - 24.5 " " " " "
TC #10 - 31.5 " " " " "
TC #11 - 38.5 " " " " "

The two most noteworthy aspects in Figures 9 and 10 are: (1) the reactor temperature came up approximately to the set point temperature within 30 minutes as discussed in connection with Figure 8; and (2) that temperature profile as indicated by thermocouples #6-9 in particular indicate that approximately 35 inches (from the top of the reactor to a point midway between thermocouples #9 and #10) were effective in promoting the reformation reaction. That is, in spite of the Fiberfax™ insulation at the bottom of the tube furnace stack, some air was aspirated and this cooled the bottom end of the reactor. However, the effect of this cooling diminished rapidly away from the effluent end of the reactor, and was relatively inconsequential somewhere between thermocouples #9 and #10. This implies that approximately 35 inches of the 42 inch reactor length, or 83% of the reactor or catalyst volume was at- or sufficiently close to- the set point temperature that it can be regarded as being effective.

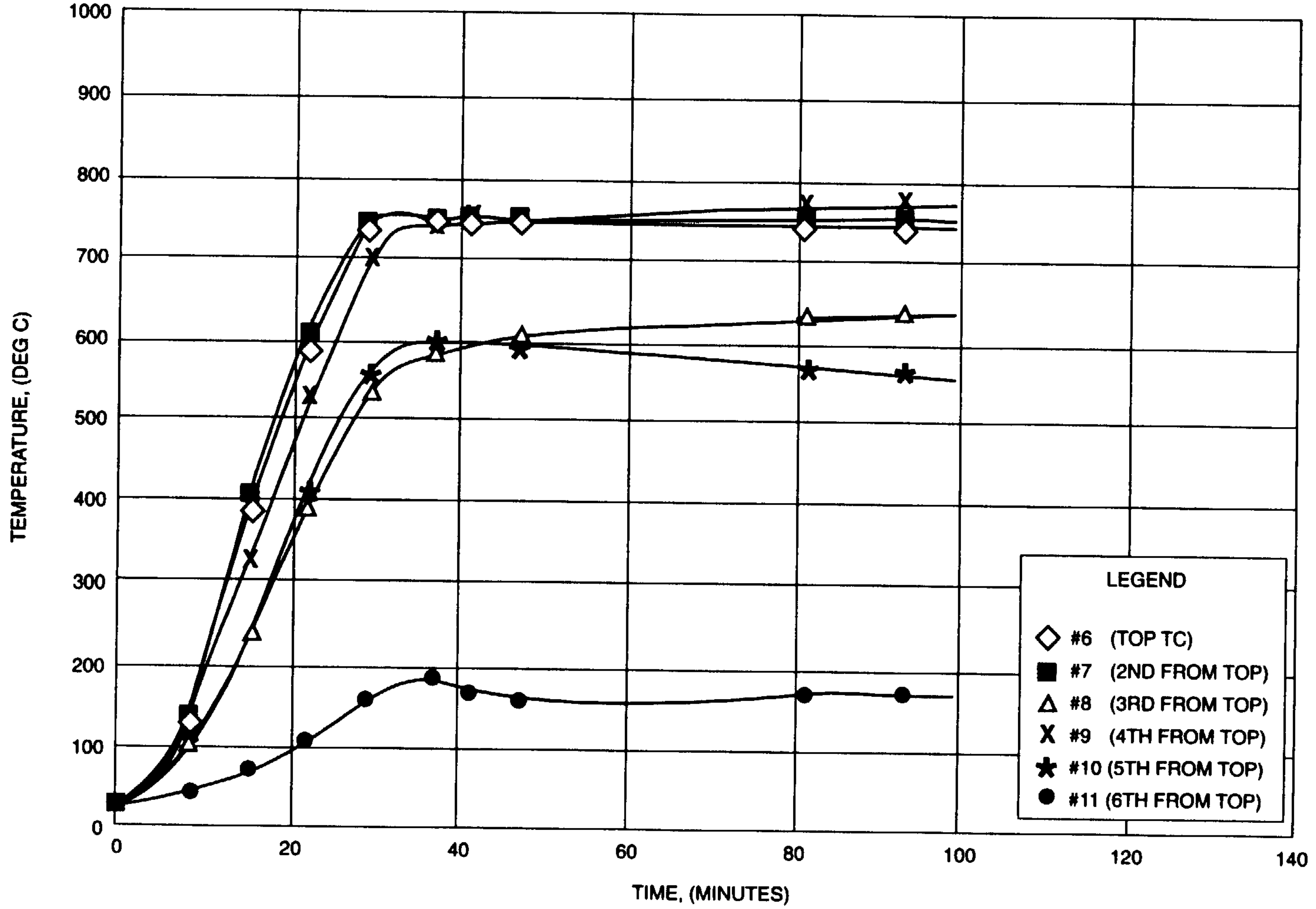

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Figure 9 Reformer Temperatures - Run #4 (Nom 1400°F)

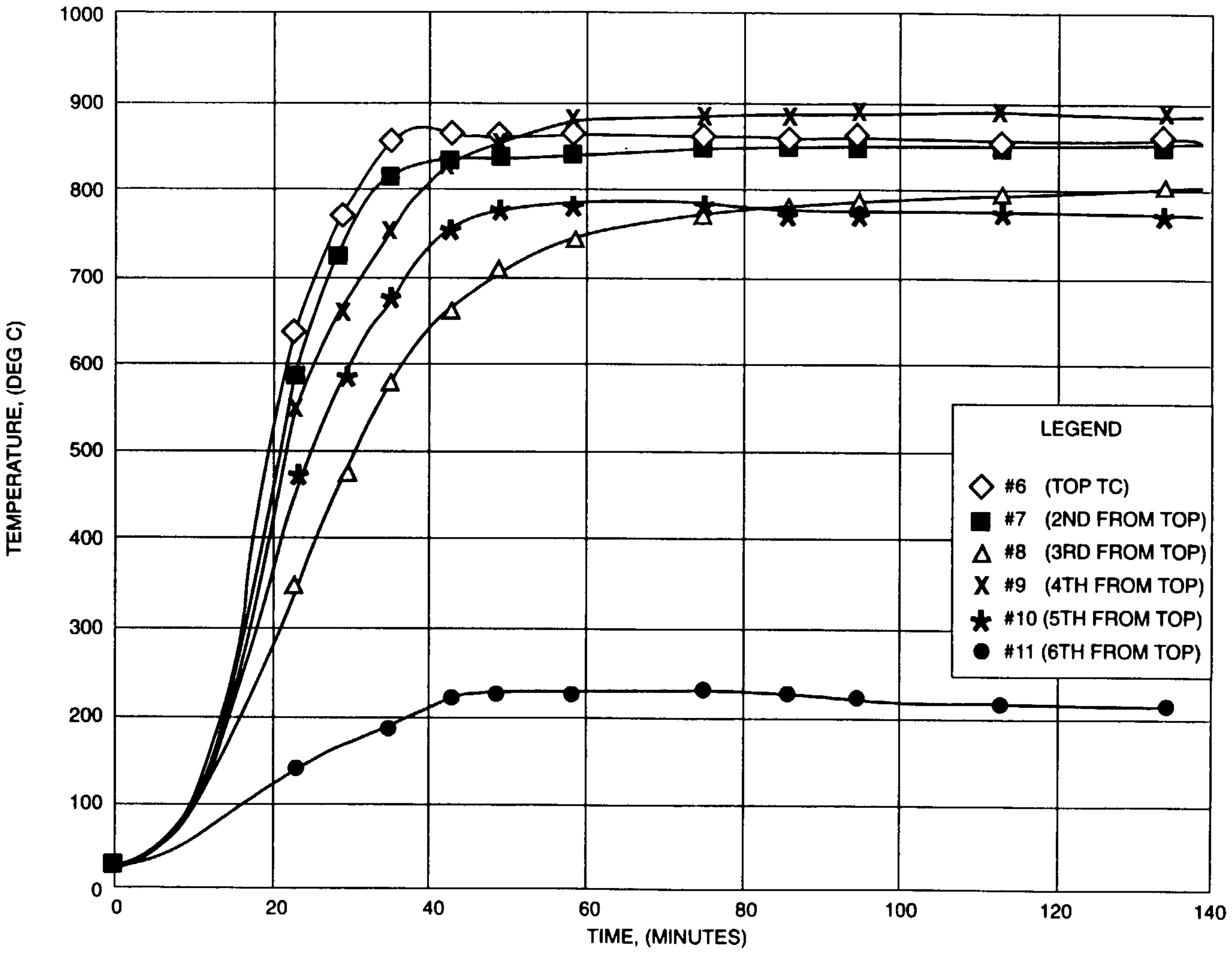

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Figure 10 Reformer Temperatures - Run #22 (Nom 1600°F)

4.0 Experimental Results

The most notable results from this investigation are:

1. The addition of as little as 3% oxygen in steam at approximately 1400°F appears to suppress the formation of a carbonaceous char during gasification, and therefore passes any remaining organic content on to the reformer as a vapor.
2. The Nickel / Cobalt reforming catalyst (Harshaw Ni-1601) used in this work proved extremely effective (90-99%) for breaking down even stable compounds such as methane and ammonia; at least where the reform stream featured some oxygen content.

In addition, since the Nickel/Cobalt catalyst retained its activity in spite of repeated contact with nitrogen and sulfur containing effluent steam reforming streams, the indications from this work are that it has the potential for a developable useful life. Steam reformation at 1600°F with the Nickel / Cobalt catalyst also virtually completely destroyed complex odoriferous organics including those which started with sulfur, nitrogen, or organic acid content (methionine, Igepon™ TC-42, butyric acid). However, this does not necessarily mean that all organics are eliminated with use of the Nickel/Cobalt catalyst. It was seen that in addition to trace quantities of residual methane detected in the reformer effluent, the condensibles from the reformer frequently had a napthalenic (moth ball) odor and may have contained other organics as well. Unfortunately, the scope of this effort could not accommodate more than the presented analysis of the condensate liquids trapped, and a more quantitative review must be left for future work.

The total amount of data accumulated during the 24 runs is extensive. The gasification and reform temperatures, initial charge- and char- masses (where gasification was incomplete), and other specifics of the experiment conducted were presented in Table I. The color, odor and pH of the liquid condensates recovered from the gasifier and reformer cold traps are shown in Table IV. A chronology of the instantaneous flows: water (steam); inert gas (helium or in the case of Run #1, nitrogen) and oxygen is presented on a run-to-run basis in Appendix A of this report. Finally, a complete set of the original recorded data is available from the data sheets comprising Appendix B of this report.

Table IV Steam Reformation of Various Organics

Run	Material	Temperatures Gasifier (Deg F)	Temperatures Reformer (Deg F)	Oxygen Conc. (per cent)	Reformer Catalyst	Gasifier Trap Color	Gasifier Trap Odor	Gasifier Trap pH	Reformer Trap Color	Reformer Trap Odor	Reformer Trap pH
1	cellulose	1200	1400	-	none	straw color, slightly cloudy	mild	3	-	-	-
2	cellulose	1200	1400	-	none	straw color, slightly cloudy	mild	3.5	clear	none	5
3	cellulose	700	1400	-	none	amber, slightly cloudy	mild	3.5	clear	none	5
3a	cellulose char	1200	1200	-	none	straw color, slightly cloudy	trace napthalenic	4	-	-	-
4	cellulose	1200	1400	9.0 %	none	straw color, slightly cloudy	mild	4	clear	mild napthalenic	5
5	cellulose	1400	1400	3.2 %	none	clear straw	mild	4.5	clear	mild napthalenic	5
6	urea	1400	1400	2.7 %	none	clear straw	mild NH_3	9	clear straw	strong NH_3	11
7	urea	1400	1600	1.1 %	none	-	-	-	clear straw	strong NH_3	11.5
8	Igepon TC-42	1400	1400	3.2 %	none	yel w abund lt. brn, floc preci	light napthalenic	9.5	cl. straw w tr. lt. brn precip	light napthalenic	8
9	cellulose (1) (wheat straw)	1400	1400	3.3 %	none	cl. straw w tr. lt. brn precip	napthalenic	4	cl. straw	napthalenic (1)	2 (1)
10	Igepon TC-42	1400	1600	3.9 %	none	lt. yel. w trace blk. sediment	napthalenic	2	lt. yel. w trace lt. brn. sed.	slight	7.5
11	Igepon TC-42	1400	1600	3.2 %	none	clear wi tr. blk. sed.	slight	2.5	clear w amb floculent	napthalenic	3.5
12	polyethylene	1400	1600	2.9 %	none	clear	trace napthalenic	2.5	clear w insol dk. brn oils	napthalenic	2
13	sucrose	1400	1400	-	none	yel / amber	trace napthalenic	2.5	clear / lt. yel	none	3.5
14	cellulose	1400	1600	-	none	clear / pale yel	slight	3.5	clear, yel /amb	slight	4.5
15	cellulose char	1400	1600	-	none	clear	light napthalenic	6	lt. amber	light napthalenic	4
16	butyric acid	1400	1600	2.1 %	none	-	-	-	clear	light napthalenic	6
17	methionine	1400	1600	0.0 / 2.1 %	none	-	-	-	clear / lt. amb.	napthalenic	8
18	polyethylene	1400	1600	7.4 %	ruthenium	opaque, dk br	strong napthalenic	2	opaque, dk br	charred organic	2
19	polyethylene	1400	1600	3.0 %	nickel	clear w. slight tar	sl. burnt plastic	4	clear	nitric odor	2
20	methionine	1400	1600	3.7 %	nickel	brn, wi tars	ext strong fecal/charred rubber odor	8	clear	none	2
21	urea	1400	1600	3.1 %	nickel	clear	NH_3	10.5	clear	none	2
22	Igepon TC-42	1400	1600	11.2 %	nickel	clear / lt. amb	napthalenic	8	clear	light napthalenic	3
23	Referee Mix (2)	1400	1600	3.5 %	nickel	amber / lt brown	strong fecal/ napthalenic	9	clear	none	2
24	Referee Mix (2)	1400	1600	3.5 %	nickel	brn, wi tars	ext strong fecal/charred rubber odor	8.8	clear	none	6

(1) The wheat straw was received from NASA Ames on 12-4-95. The straw may have had a nitrate content to effect the observed pH.

(2) The Referee Mix used was comprised of: 10 wt % polyethylene; 15% urea; 50% cellulose (25% Avicel PH-200 + 25% wheat straw, added for consistency); 20% IgeponTC-42; and 5% methionine. The resultant mix was then blended with 39% added water to form a paste.

In addition to the results discussed earlier with respect to the catalytic breakdown of methane and ammonia, the color of the catalytically reformed gasifier effluents was uniformly clear as shown in Table IV. The condensate from the reformer reactor in Run #19 had a nitric acid odor but neither the acid concentration in Run #19 or the ammonia concentration in Runs #6-7 were quantified. A number of both the gasifier and reformer effluents has the moth ball odor of napthalene ($C_{10}H_8$), but it is difficult to estimate the absolute concentrations involved. Napthalene is essentially insoluble in water, and since there was no observable second phase present in most of condensate specimens collected, it seems that the absolute quantity of napthalene produced must have been negligible.

4.1 Oxygen Stoichiometry

The tabulations of both Table I and Table IV of this report present both the actual (mean) inlet oxygen concentration and the total oxygen as a percent of the stoichiometric requirement. The inlet oxygen concentration was typically 3-4% except for Runs #4, #18 and #22. It was only 1-2% in Runs #7 & 16, and in Runs #1-3a and #13-15 there was no oxygen addition at all. However, the interpretation of total oxygen in terms of the stoichiometric requirement includes a number of uncertainties. Clearly, oxygen passing through a cold reactant mass will not be effective in promoting gasification. Likewise, even though the reform reactor might have reached a steady state operating temperature, oxygen passing through it cannot be utilized if the volatilization of organic molecules in the gasification reactor has not started. Finally, if a "slug" of reactant is volatilized in a relatively short time interval (this appears to occur at least with urea) - whereas the oxygen flow is approximately constant - there will be an insufficient supply of oxygen to accommodate any anticipated reaction during the period of slug reactant flow. There will also be insufficient reactant prior to- and after- the period of slug reactant flow to utilize the available oxygen. Therefore, the entries in the column showing oxygen as a percent of the stoichiometric requirement in Table I must be considered *maximum* values. To achieve the results shown in Table I, some oxygen addition is required, but not as much as shown in the Table. Thus, under the experimental conditions, it is inevitable that some fraction of the total oxygen supplied will not participate in either the gasification or reform reactions. To minimize the overestimate, at least on the front end of a run, the integration of total oxygen throughput was started from the time a "minimum reactive temperature" was reached (approximately 30 minutes into a run) rather than from the time a run was initiated. The temperature of the gasifier charge at this time was approximately 160-200°C as shown in Figure 8. Thus, in calculating the overall stoichiometry for Table I, all oxygen flow between the time the gasifier charge first reached 160-200°C and the time when the oxygen flow was terminated was considered "effective". The amount of conservatism incurred from this treatment undoubtedly varies according to the chemistry of the different model compounds tested and the particular temperature cycle.

The following section includes discussion of steam reforming results obtained with each of the model compounds. The reduced data for each run showing the instantaneous flow rate and composition of the gasifier and reformer effluents - from which the stoichiometric equivalents were derived - are presented in Appendix A. In this work, a milliequivalent is a millimole of hydrogen atoms; half a millimole of hydrogen gas; or one-quarter of a millimole carbon or oxygen gas. It has the ability to make- or requires the breaking of- one millimole of chemical bonds.

4.2 Cellulose:

The gasification of cellulose is important because it is a majority constituent of nearly any waste configuration. In the tested Referee Mix cellulose and wheat straw (mostly cellulose) comprised 50% of the blend.

Although the gaseous effluent streams from the steam reformation of cellulose were perhaps the easiest to treat of all the model waste compounds tested, cellulose was perhaps the most difficult of all the model compounds tested to gasify. That is, there was a carbonaceous residue from all the tests of cellulose gasification conducted without the benefit of oxygen addition (i.e. Runs #2, 3, and #14 in Tables I and IV in addition to the incomplete volatilization of cellulose char tested in Runs #3a and #15).[3] This may have been due to the fact that cellulose appears to readily lose water at temperatures as low as 160-200°C to form a carbonaceous char which is predominantly carbon; and once formed, the char appears substantially less reactive (at least with steam) than the other organic materials tested.

A comparison of test results from the gasification of cellulose char in Runs #3a and #15 is interesting in that there is surprisingly little difference between its gasification rate at 1200°F and the rate at 1400°F. In both Runs the time of exposure was nearly 2 hours (see Appendix A); but a 200°F increase in gasification temperature resulted in only a 10% increase in quantity of char gasified. i.e. from 50% in Run #3a (1.44 grams to 0.73 grams) to 60% in Run #15.

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[3] The residue from Run #1 was also substantial, but it could not be quantified because the Gooch crucible broke during testing. The broken crucible and some of the carbon residue retrieved is shown in Figure 11. It is believed that the crucible broke during the post-test cool-down where, because the ceramic material of the Gooch crucible does not thermally expand as rapidly as Inconel with temperature, it was able to settle deeper into the gasification reactor shown in Figure 4 as it was heated, and then, during cool-down, the crucible was unable to resist the compressive load imposed as the shoulder of the gasifier element designed for crucible retention contracted against it. This hypothesis was never proven, but when the crucible was supported on a thin walled, soft copper ring which elevated the Gooch crucible approximately 0.100" above the position shown in Figure 4, starting in Run #2, there was no further crucible loss. It is also significant that after a number of runs the copper ring developed a swage at the point of contact with the crucible wall.

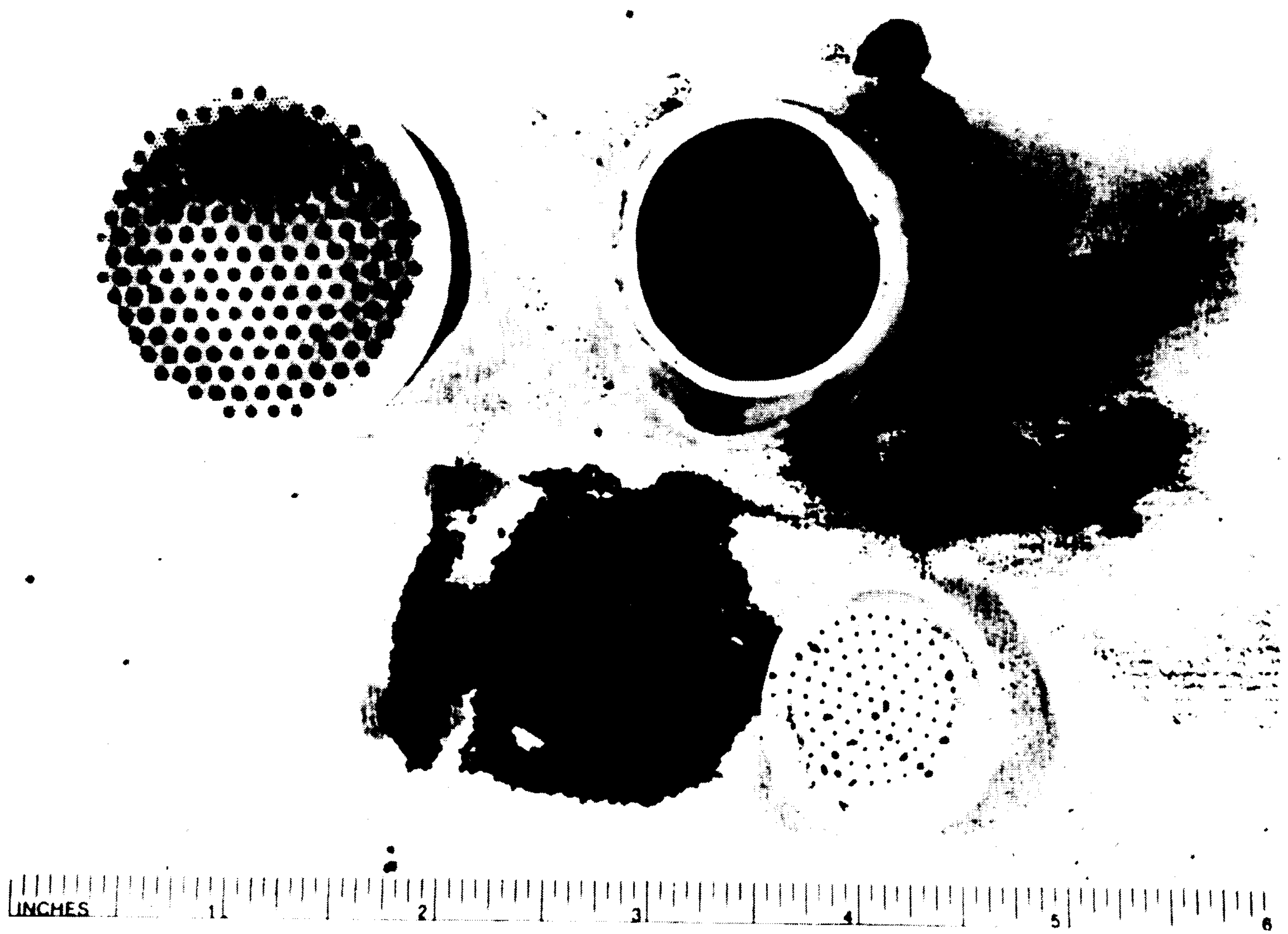


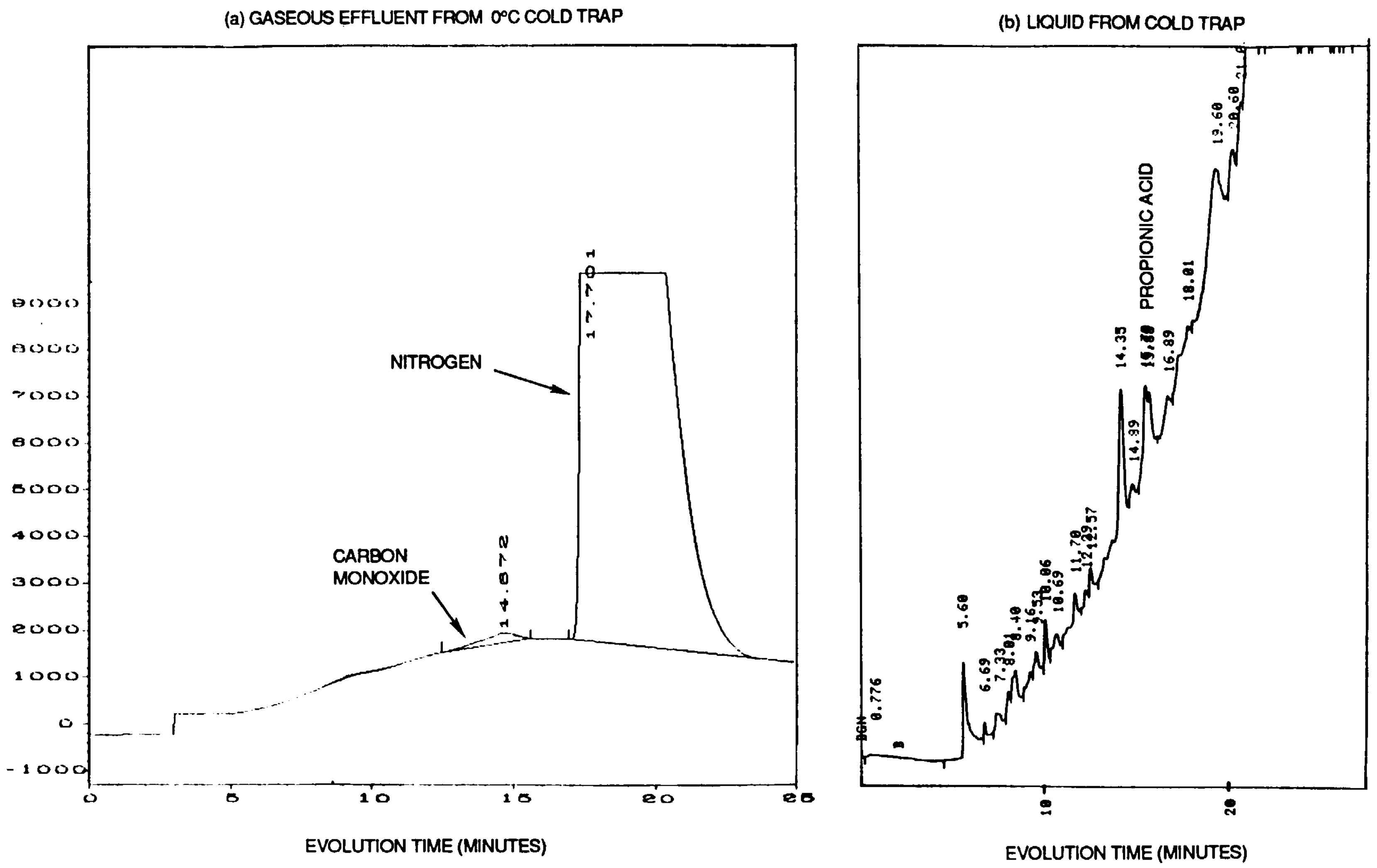
Figure 11 Photo of Filter & Broken Crucible After Run #1
(Cellulose @ 1200°F w/o Oxygen Enrichment)

4.2.1 Chromatographic Analyses of the Condensate from Cellulose Gasification

Chromatographic analysis of the condensate from cellulous gasification were performed only for the early cellulose runs while the analytic procedures were being evolved. These data are qualitative, but the information gained is interesting and consistent with many other experimental observations from this test program. However, the analysis of condensate liquids was cumbersome, and it became apparent that the correlation of observed peak height with concentration varied widely from one compound to the next. Therefore, numerous standards would have to be prepared and run along with the sample specimens in order to obtain quantitative results. The allocation of this level of effort was inconsistent with completing the survey of model waste compounds suggested in the original test matrix, and therefore analysis of the condensate liquids was abandoned after Run #4. However, all condensate liquids recovered from all the runs shown in Table I have been put into storage so that future analyses of the liquids obtained from these runs is possible.

Figure 12 depicts the results from analysis of the effluent gas stream and liquid condensate from Run #1. As shown in the figure only propionic acid (C_2H_5COOH) was identified in the condensate analysis. Both analyses were of a survey nature, and neither of the results were quantitative. However, it was clear from the extremely large nitrogen peak in Run #1 that the resolution of gaseous effluents in successive runs would be compromised unless a switch to a helium as the inert gas was made. Also all subsequent analyses of condensate liquids were made using a Hewlett-Packard #5890 Gas Chromatograph with a HP-20M Carbowax 20µ 50 meter x 0.32 mm column x 0.3µm film thickness.

Based upon this approach, the condensates from the gasifier and reformer traps in Runs #2, 3, 3a and #4 were analyzed. Of these runs, Run #3a comprised a continued exposure of the cellulose char retrieved from Run #3 to 1200°F steam (see Table I); and Run #4 was the only gasification run of this series which included oxygen (9% in steam).


(a) GASEOUS EFFLUENT FROM 0°C COLD TRAP

(b) LIQUID FROM COLD TRAP

Figure 12 Gas Chromatagaphs of Run #1 - Cellulose @ 1200°F

The condensate from the gasification reaction in Run #2 is shown in the top half of Figure 13. Peaks are observed for: (a) acetaldehyde (CH_3CHO); (b) isopropanal (C_2H_5CHO); (c) 2-Butanone - or methyl-ethyl-ketone (MEK) - (CH_3-CO-C_2H_5); (d) acetic acid (CH_3COOH); and (e) furfural ($(C_4H_3O)CHO$). However, after even a ***homogeneous*** (non-catalytic) reformation in the absence of an oxidizer, all trace of these compounds has been eliminated as shown in the bottom half of Figure 13. i.e. the additional rigor of reformation over the Nickel / Cobalt catalyst or reformation with oxygen enrichment should - if it were possible - result in an even lower residual concentration of organics.

The same results were obtained with the liquid condensates from Run #3 except that the minor peak from 2-Butanone (MEK) appearing at 2.89 min. appears to have been lost in the isopropanal peak appearing at 2.87 min, and there is the barest trace of an isopropanal peak in the reformer condensate. These results are shown in Figure 14. The only difference between Runs #2 and #3 is that in Run #3 steam gasification was conducted at only 700°F instead of 1200°F in Run #2. Both gas reformation reactions were conducted at 1400°F without any oxygen enrichment.

Two additional analyses of the gasifier condensate recovered from Runs #3a and Run #4 are of interest. These are shown in Figure 15. In Run #3a, the char produced from the gasification of cellulose at 700°F in Run #3 was subjected to continued steam gasification at 1200°F. In this run only a gasifier condensate was recovered. The gasifier effluent was not exposed to reformation as the organic yield was expected to be small and it was believed that a better resolution of the effect of the gasifier reaction would be afforded if the organic concentrations were not diminished still further by gas reformation. In the top half of Figure 15, a trace level peak from isopropanal (Retention Time = 2.89 min. in Figure 12) can be identified, but its height is at least an order of magnitude lower than that produced by the gasifier condensate from Run #3. This is consistent with the interpretation of the large endotherm attending the gasification of cellulose during the discussion of heating rates in **Section 3.2** of this report, wherein it was inferred that the pyrolytic decomposition of cellulose to a carbonaceous char was already well underway at 160°C. A chromatographic analysis of the gasifier condensate recovered from Run #4 is shown in the bottom half of Figure 15. A fresh cellulose charge in Run #4 was the first steam gasification run conducted with oxygen enrichment; and the mean oxygen concentration in steam was 9% (see Table I). From the chromatographic analysis the presence of acetaldehyde and 2-Butanone is visible but as in Run #3a the organic concentrations are diminished by at least a factor of 10 relative to treatment with steam alone. A chromatographic analysis of the reformer condensate was also obtained from Run #4, but as with the reformed samples shown in Figures 13 and 14, no organic constituents were detectable.

4.3 Urea

Urea was gasified - with oxygen enrichment - in Runs #6, 7 and #21. The reform reaction was conducted over a Nickel / Cobalt catalyst in Run #21; the reformation was non-catalytic in the other two runs. Slight difficulty was experienced with the system plugging-up in all three runs. Urea melts at 135°C and decomposes before it is vaporized. However, there was only a slight odor of ammonia in the gasifier condensate from Runs #6-7 whereas a strong ammonia odor was noted in the (non-catalytic) reformer condensate from these runs. These data imply that a substantial fraction of the urea was volatilized without decomposition coming out of the gasifier. However, the additional time of high temperature exposure - the reformer was at the same temperature as the gasifier (1400°F), in Run #6 but the residence time was nearly ten times as great - resulted in substantial decomposition producing ammonia as a principle product. This hypothesis is substantiated by the increase in pH from approximately 9 to 11 (see Table IV) incurred when the gasifier effluent was reformed. Finally, the effect of the Nickel / Cobalt reformer catalyst in Run #21 was to completely decompose any ammonia produced. Instead, the very low pH of the reformer condensate in Run #21 (pH = 2) is indicative that an acid was produced. The fact that this pH is much more acidic than can be attributed to dissolved CO_2 (i.e. carbonic acid), and the absence of any residual odor of ammonia implies that the catalytic reaction of ammonia in oxygen enriched steam may go beyond the production of molecular nitrogen to nitric acid.

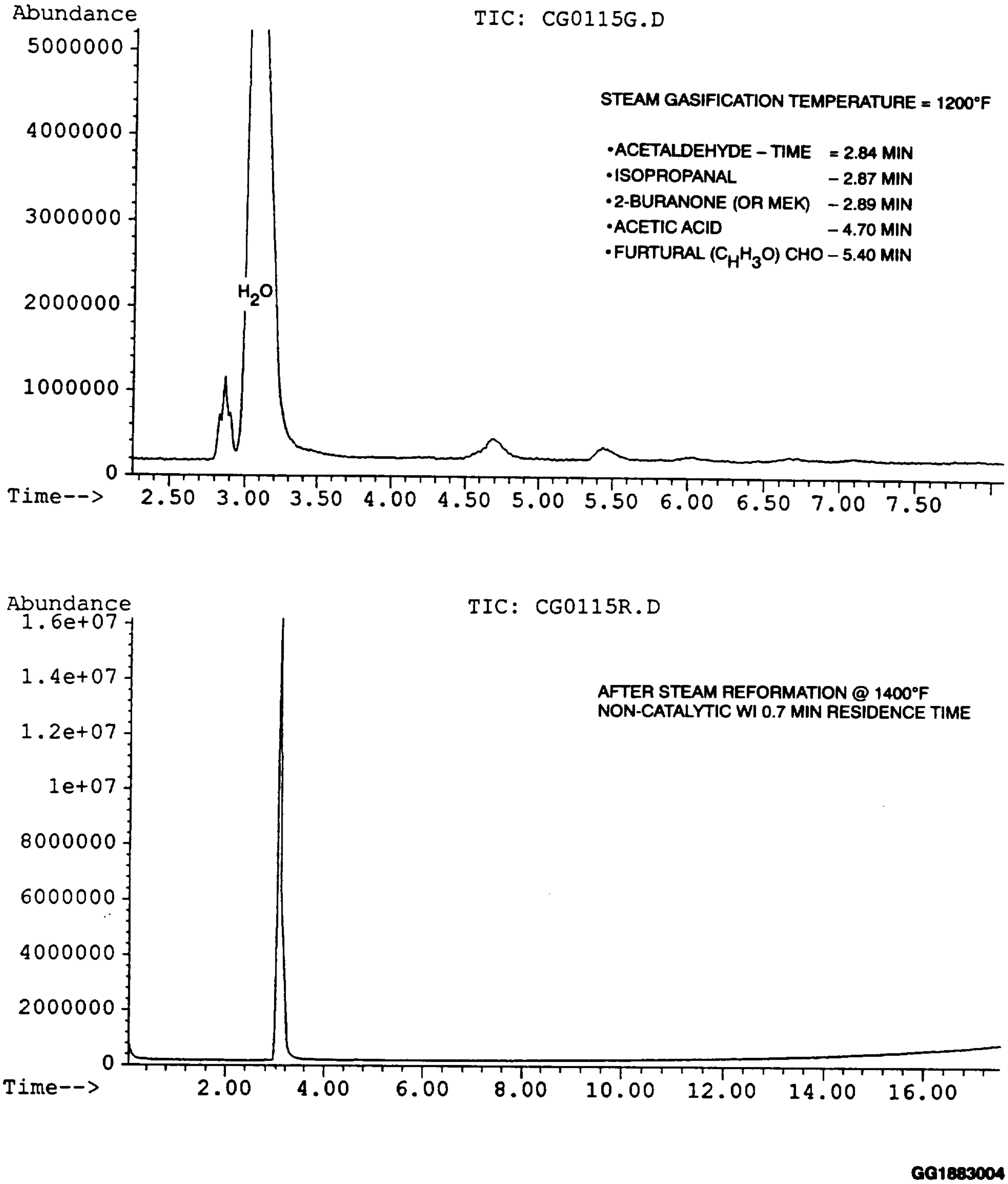


Figure 13 Chromatographic Analyses of Gasifier & Reformer Condensates from Run #2 Cellulose @ 1200°F

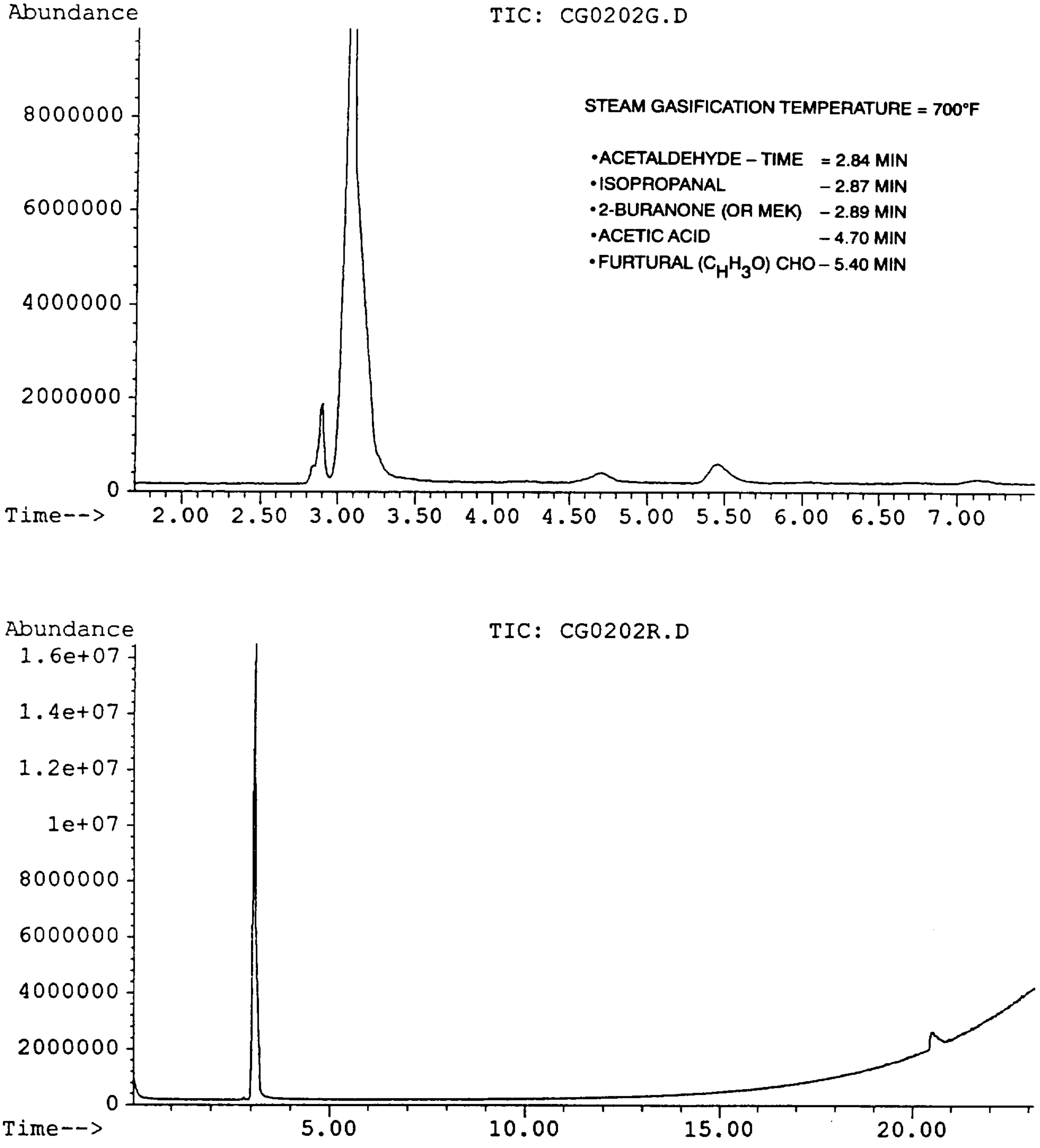


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Figure 14 Chromatographic Analyses of Gasifier & Reformer Condensates from Run #3 Cellulose @ 700°F

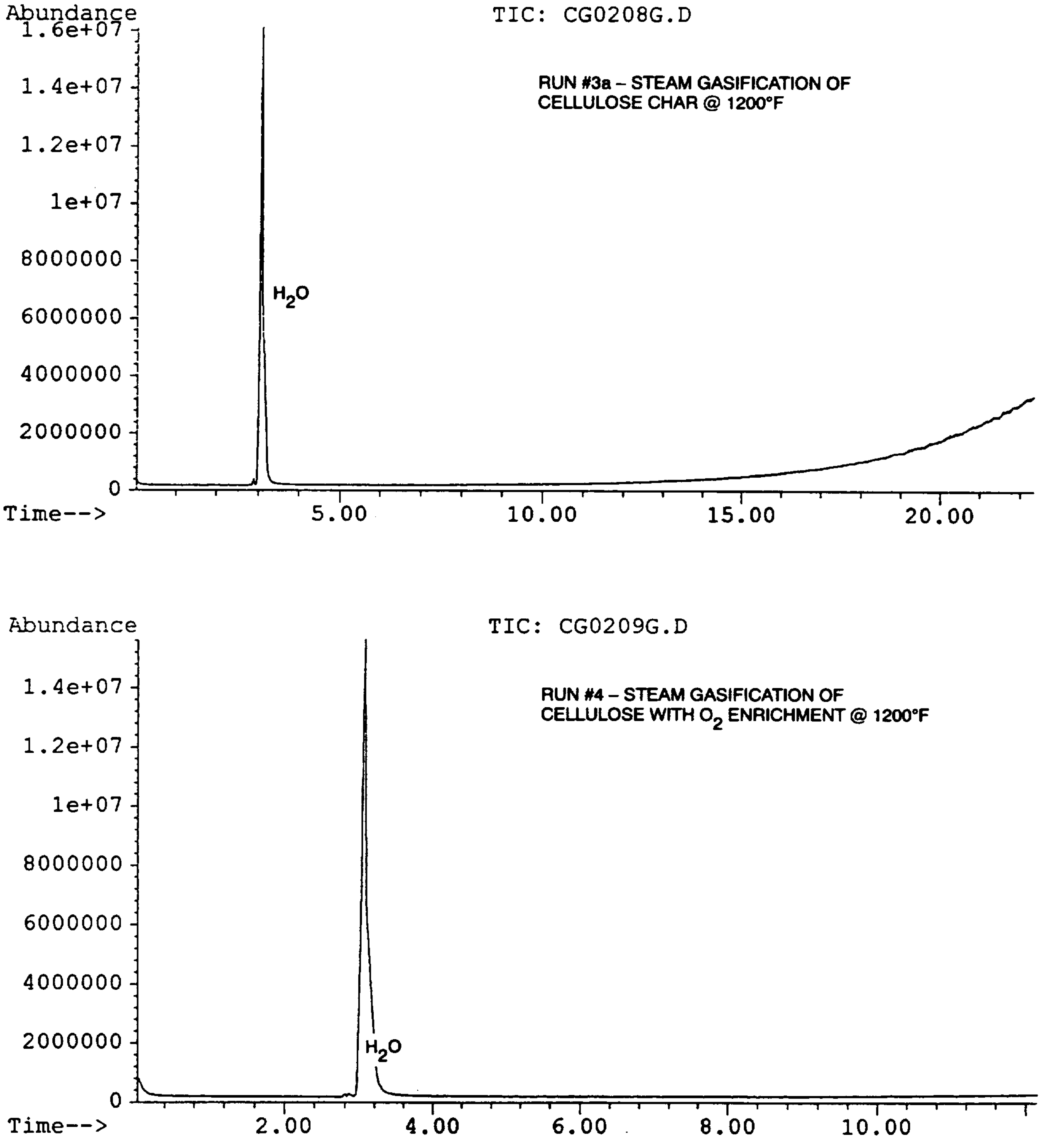

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Figure 15 Chromatographic Analysis of Gasifier Condensates from Run #3a (Cellulose Char) & Run #4 (Oxygen Enrichment)

4.4 Igepon^{TM} TC-42

The steam reformation of Igepon^{TM} TC-42 was conducted in Runs #8, 10, 11 and #22. All of the gasifications/reformations were conducted with oxygen enrichment and no carbonaceous residues were observed from any of the runs. Sodium chloride (NaCl) is a substantial constituent of Igepon^{TM} TC-42, and it was retained by the alumina in the gasification crucible. The composition of both gasification and reformer effluent gas streams, even from the catalytic reformation, were rich in molecular nitrogen. This observation alone does not mean that there was not some nitric acid production. The pH of the catalytically reformed effluent was less acidic than the reformed effluent from the gasification of urea (pH = 3); but there was an order of magnitude less nitrogen to begin with. The pH results from the uncatalyzed reformates are not in agreement (i.e. 8 and 7.5 in Runs #8 & 10 vs. 3.5 in Run #11).

4.5 Wheat Straw

Wheat straw from NASA Ames was run as a pure compound in Run #9, and as a 25% constituent of the Referee Mix tested in Runs #23-24. The straw material was highly fiberous, and in the Referee Mix it provided bulk and model paste-like consistency. Although straw is highly cellulosic, the wheat straw was readily gasified with only 3% oxygen enrichment without any carbonaceous residue. The ash resulting from its gasification in Run #9 is shown in Figure 16. In this figure the Gooch crucible at left was filled almost to the brim with wheat straw (because of its fiberous bulk it weighed only 3.58 grams). After gasification a highly porous inorganic (gray) ash was recovered. This is shown in the right-hand side of Figure 16. The ash weight was approximately 0.3 grams as shown in Table I.

4.6 Polyethylene

The steam reformation of polyethylene was accomplished by mixing, by weight, approximately 3 parts of an aluminum oxide support with 1 part polyethylene squares as shown in Figure 17. The alumina retained enough of the plastic material - which melted - to prevent the molten reactant from plugging the holes in the bottom of the Gooch crucible. All three runs polyethylene runs: #12; #18 (with the ruthenium catalyst), and #19 with the

Nickel/Cobalt catalyst resulted in the production of a highly acidic effluent as evidenced by the low pH values observed in Table IV for both gasifier and reformer condensates in all three runs. In fact, the condensate from the Nickel/Cobalt reformation (Run #19) was the only instance in which the Nickel/Cobalt reformate had any odor at alll, and the odor was that of nitric acid. The source of the high acidity is not known at this time, and the need for additional data is indicated.

4.7 Sucrose

The steam reformation of sucrose in Run #13 was conducted without oxygen enrichment and with about the same result as was obtained in the case of cellulose gasification. As with cellulose, decomposition to steam plus a carbonaceous residue should be anticipated at a temperature as low as 160-200°C. After that, at least in the absence of oxygen enrichment, complete gasification is difficult. However, sucrose readily melts whereas cellulose does not. Thus, sucrose poses a much greater threat to plug the reactor system. This occurred at t+53 minutes into Run #13 as indicated in Table I, and due to the fact that (other than its susceptibility to melting) the chemistry of sucrose is so similar to cellulose there appeared little benefit in conducting any additional runs with a sucrose reagent.

4.8 Butyric Acid and Methionine

Only gasification followed by reformation was conducted in the case of the non-catalytic runs with butyric acid (C_3H_7COOH) and methionine (CH_3-S-$CH_2CH_2CHNH_2$-COOH) in Runs #16 and #17. This is because both compounds are relatively volatile, and an extremely strong odor was anticipated if a volatile effluent was allowed to escape with only partial decomposition (i.e. gasification only). The mercaptan (-S-) linkage in methionine was anticipated to contribute to an extremely strong, objectionable odor. However, the condensate from both reformed effluents was clear and clear to light amber for butyric acid and methionine respectively. The pH values observed were near neutral, (pH = 6 & pH = 8 respectively), indicating that neither the organic acid groups or ammonia was able to make it through the reformer without reaction. A light napthalenic odor was detected with both effluent condensates, but as discussed at the beginning of this section, no second phase was detected in the condensate, and as napthalene is insoluble in water, the amount of napthalene produced must have been small.

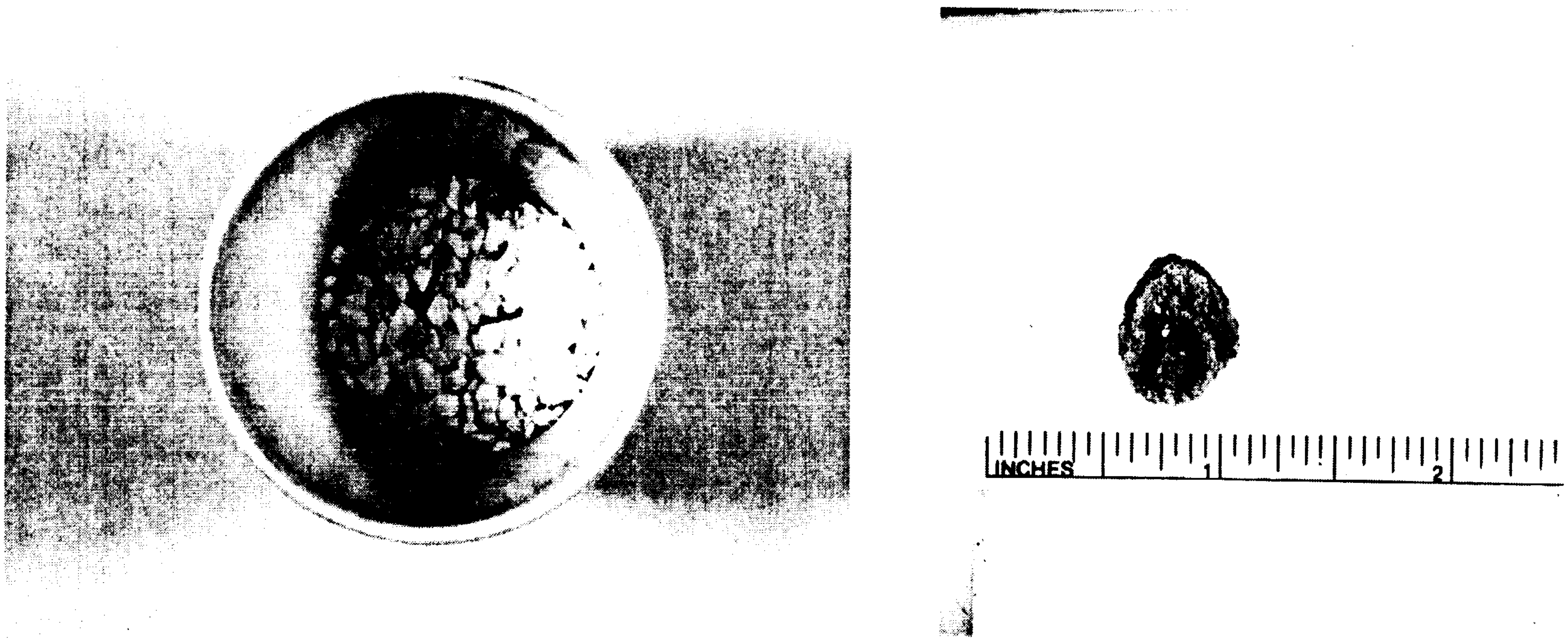


Figure 16 Residual Material from Steam Gasification of Wheat Straw @ 1400°F: (a) Gooch Crucible Showing Support of 8-14 Mesh Al2O3 (Left); (b) Pumice Like (inorganic) Residue from Gasification (right)

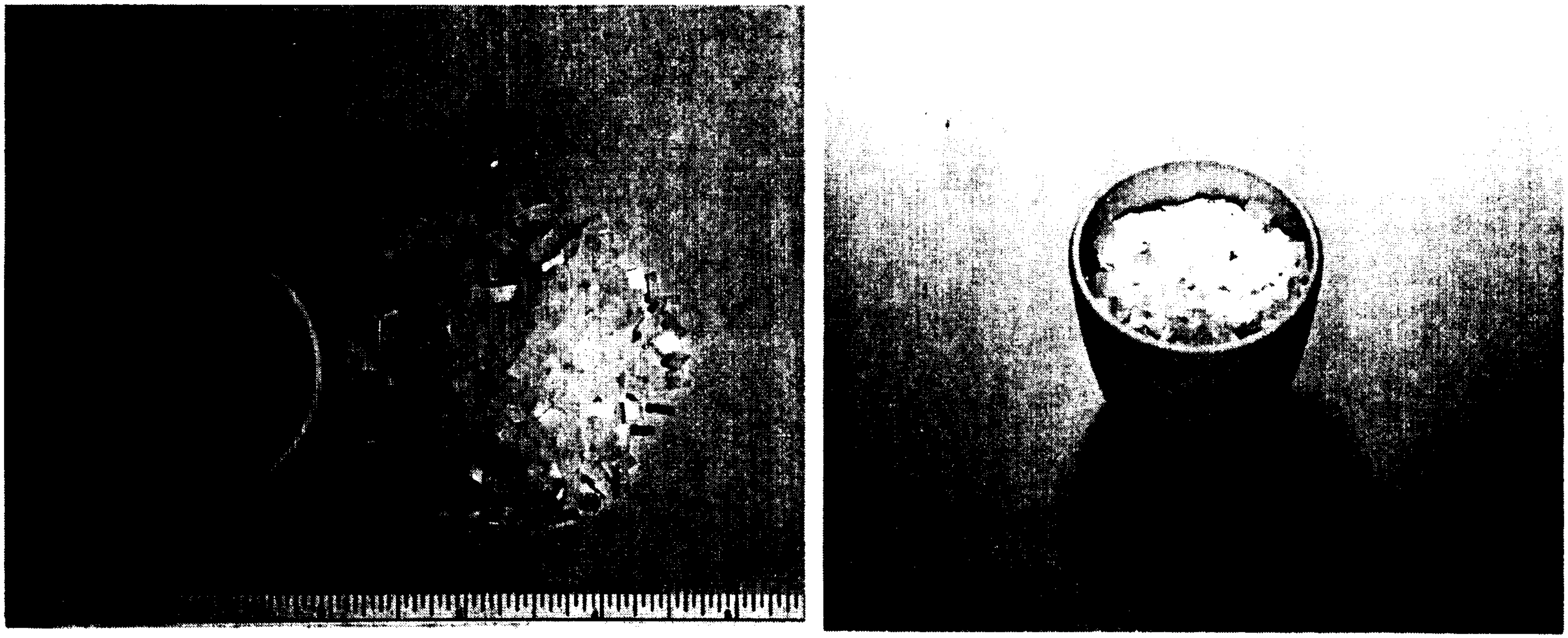
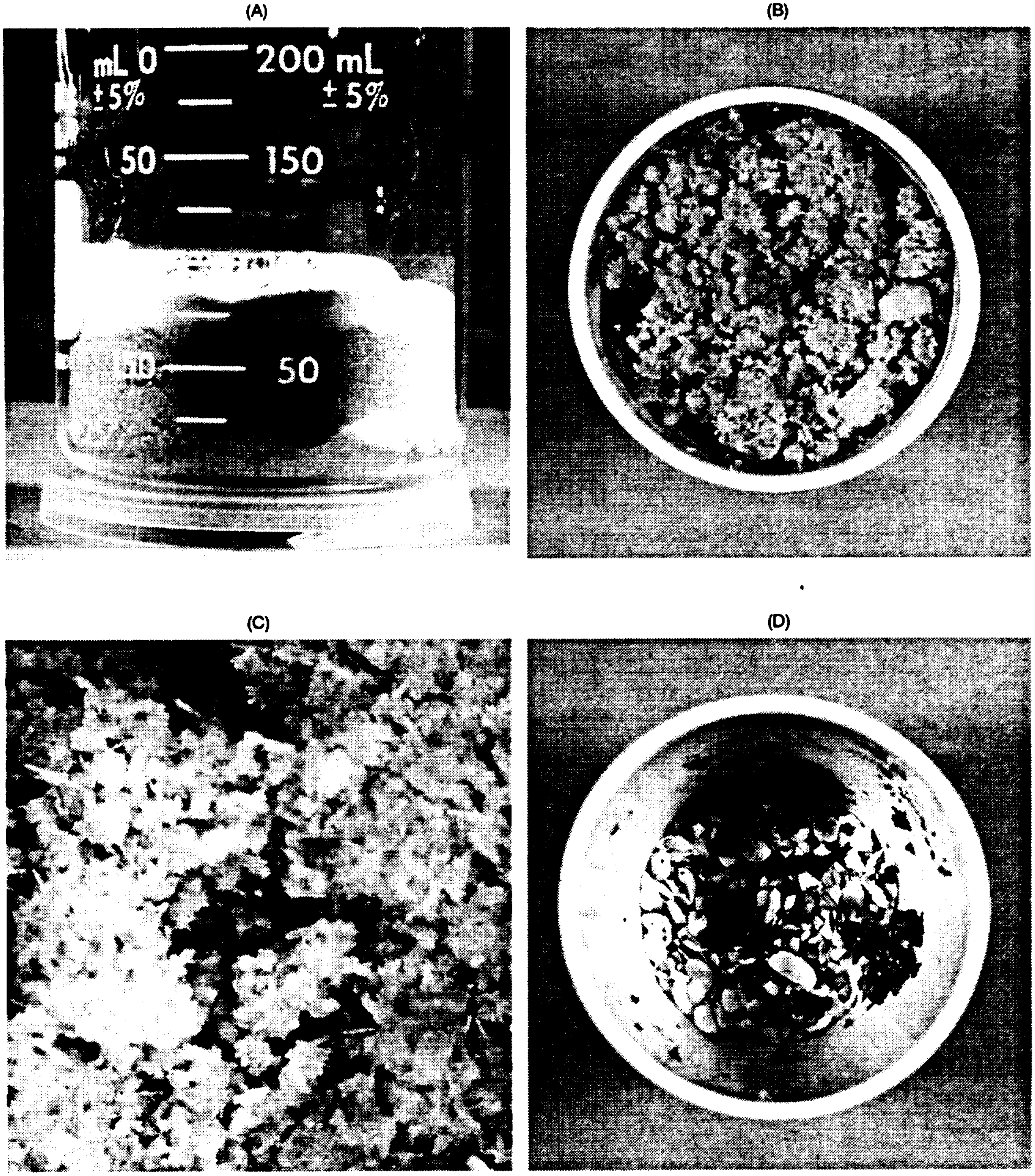


Figure 17 Sample of Polyethylene prior to Gasification: (a) Gooch Crucible with Polyethylene charge (left); (b) Loaded crucible ready for test

However in Run #20 with a powerful reforming catalyst in place, samples of the methionine condensate were recovered after gasification only. As noted in Table IV, this liquid had an extremely strong odor. The odor was characteristic of some combination of feces and burned rubber. The pH was approximately neutral. However, the condensate from the catalytically reformed effluent had no odor at all but was strongly acidic, suggesting that at least some of the nitrogen in the amine grouping went to NO_2 , the sulfur in the mercaptan linkage to SO_2 , or both.

4.9 Referee Mix

The Referee Mix tested in Runs #23-24 was comprised of 10% polyethylene; 15% urea; 25% cellulose (Avicel PH-200); 25% wheat straw; 20% Igepon^{TM} TC-42; and 5% methionine. The dry solids were then combined with 39% water (i.e. 61% dry solids of the preceding composition). This formulation yielded a pastelike blend as shown in Figure 18. Both runs benefitted from the Nickel/Cobalt reformation catalyst. As noted in Table IV both runs were conducted with 3.5% oxygen enrichmentand the reformer condensates were colorless and had no odor at all in spite of the extremely noxious effluent (and condensate) effluent from the gasifier.



(A) UNMIXED DRY COMPONENTS PRIOR TO BLENDING; (B) AS BLENDED WITH 39 W/O % WATER; (C) MICROGRAPH (@ 6.6X) OF (B) SHOWING BINDING EFFECT OF FIBROUS WHEAT STRAW MATERIAL; (D) RESIDUE AFTER STEAM GASIFICATION WITH APPROX. 5% OXYGEN FOR 30 MIN.

GG1630001cw

Figure 18 Synthesis and Test of Referee Mix @ 1400°F (a) Unmixed dry components prior to blending; (b) as blended with 39 w/o water; (c) micrograph (@ 6.6x) of (b) showing binding effect of fibrous wheat straw material; (d) residue after steam gasification with approximately 5% oxygen for 30 min.

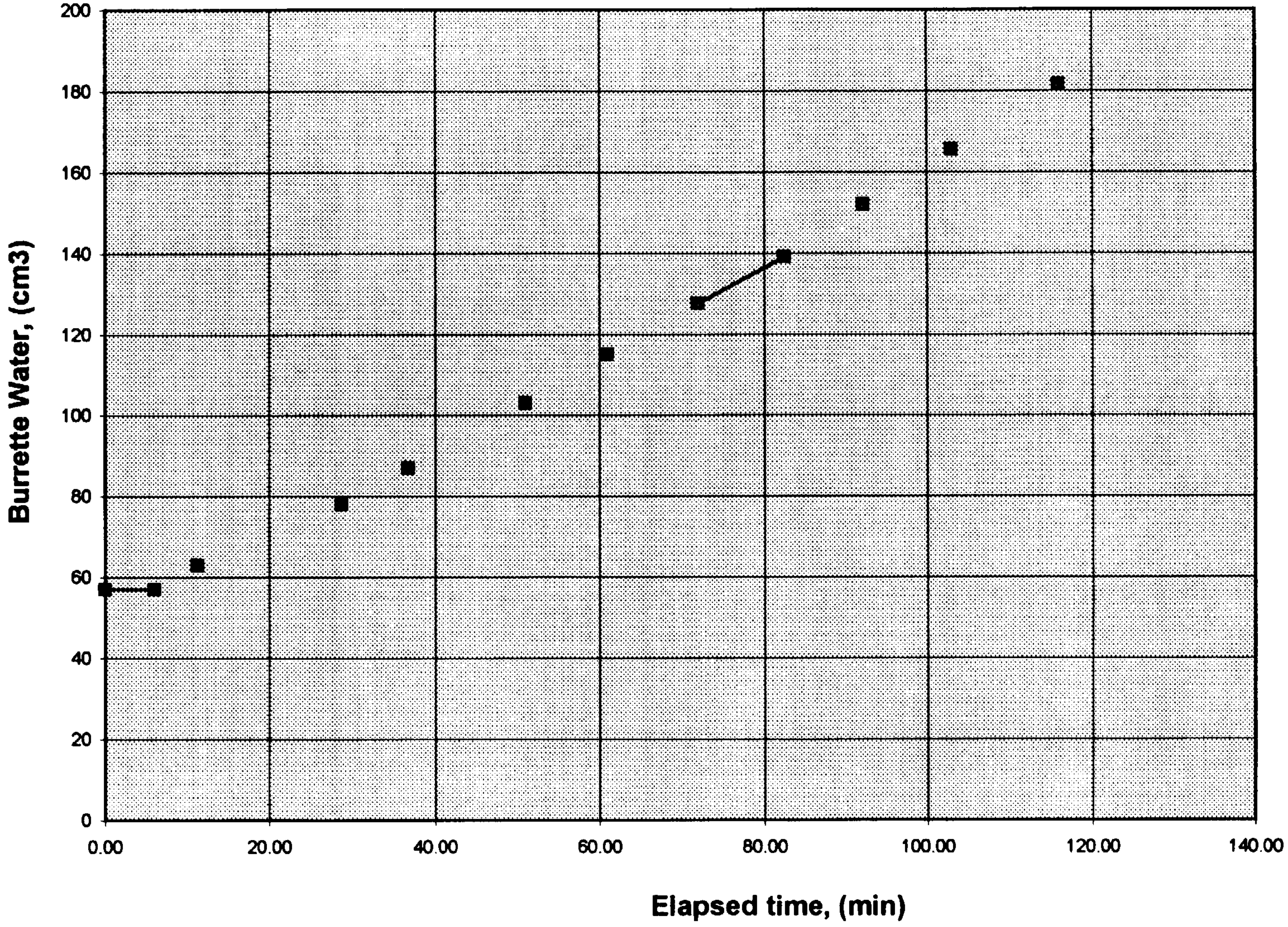
Appendix A

Gasification Flows, and
Effluent Gas Compositions

Run #2; Cellulose @ 1200°F - Jan 12, 1996

Time	Elapsed Time of Test (minutes)	Water Flow Burrette (cm^3)	(cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow (min/100 cc)	(scc/min)
10:00	0.00	57.0	0.0	gasifier	- /90	-	114.0
10:06	6.00	57.0	|	|	- /95		114.0
10:09:30	9.50		|	|			114.0
10:11:18	11.30	63.0	V	|			114.0
10:17	17.00		1.13	|	- /90		114.0
10:20	20.00		1.13	|			114.0
10:23:45	23.75		1.13	|			114.0
10:22	22.00		1.13	|	- /90		114.0
10:26	26.00		1.13	|	- /90		114.0
10:28:40	28.67	78.0	1.11	|			114.0
10:33	33.00		1.11	|			114.0
10:37:20	37.33		1.11	|			114.0
10:36:45	36.75	87.0	1.12	|			114.0
10:34:30	34.50		1.12	V	- /90		114.0
10:38	38.00		1.12	reformer			53.8
10:45	45.00		1.12	|	107/90		37.0
10:51	51.00	103.0	1.20	|		4:26	22.6
10:53	53.00		1.20	V	100+/90	1:59	50.4
11:00	60.00		1.20	gasifier	- /90		114.0
11:01:00	61.00	115.0	1.14	|			114.0
11:10	70.00		1.14	|	- /88		114.0
11:11:30	71.50		1.14	|			114.0
11:18	78.00		1.14	|			114.0
11:12	72.00	127.5	1.10	|	- /89		114.0
11:22:25	82.42	139.0	1.33	|			114.0
11:24	84.00		1.33	V			114.0
11:25	85.00		1.33	reformer			50.4
11:31	91.00		1.33	|	110/82		38.5
11:32:10	92.17	152.0	1.25	|			36.2
11:39	99.00		1.25	|			68.3
11:41	101.00		1.25	|	115/89		61.5
11:43	103.00	165.5	1.23	|			54.8
11:46	106.00		1.23	|		2:14.5	44.6
11:56:00	116.00		1.23	|			44.6
11:53	113.00		1.23	|	118/89.5		44.6
11:56	116.00	181.5	(water off)	V			44.6
12:02	122.00		furnaces off				44.6
12:04	124.00				77/82		44.6

Run #2: Cellulose @ 1200 F

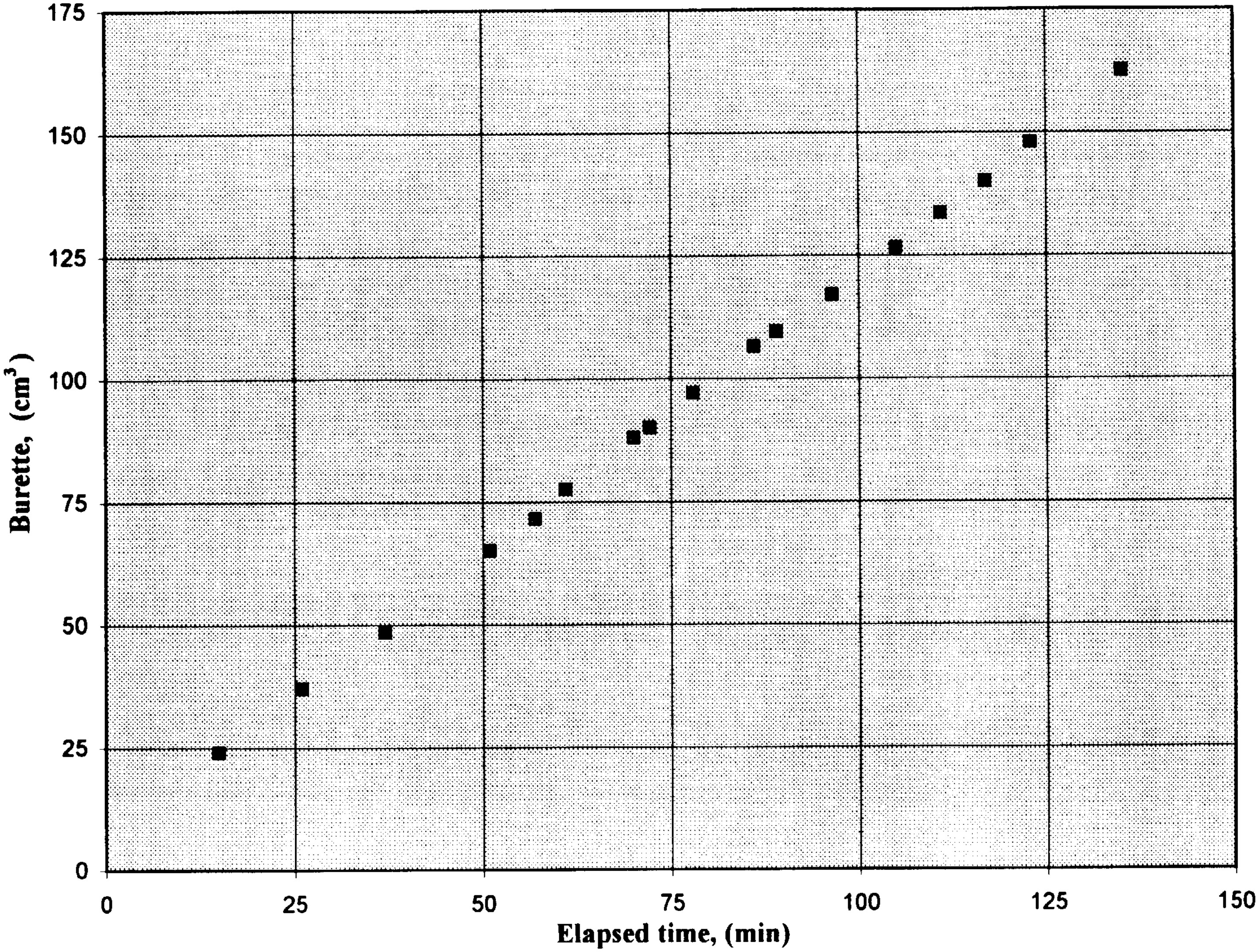


Run #3; Cellulose @ 700°F - Jan 31, 1996

Time	Elapsed Tim of Test (minutes)	Water Flow		Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow	
		Burrette (cm^3)	(cc/min)			(min/100 cc)	(scc/min)
1:30	0.00		0.0			-	100
1:34	4.00		|				|
1:36	6.00		|				|
1:41	11.00		|				|
1:45	15.00	24.0	|				|
1:50	20.00		|				|
1:53	23.00		|				|
1:54	24.00		|				|
1:56	26.00	37.0	|				|
2:00	30.00		|				|
2:05:5	35.83		V				|
2:07	37.00	48.5	(water in)	gasifier			|
2:09	39.00		1.18	|	- /90		|
2:13	43.00		1.18	|	- /90		|
2:16	46.00		1.18	|			|
2:18	48.00		1.18	|			|
2:21	51.00	65.0	1.25	|			|
2:24	54.00		1.25	|			|
2:27	57.00	71.5	1.25	V			|
2:31	61.00	77.5	1.12	reformer	- /89		|
2:33	63.00		1.12	|	- /89		|
2:38	68.00		1.12	|	- /89		|
2:40	70.00	88.0	1.12	|			|
2:42	72.00		1.12	|			|
2:42:1	72.17	90.0	1.20	|			|
2:45	75.00		1.20	|	- /89		|
2:48	78.00	97.0	1.14	|			|
2:49:5	79.83		1.14	|			|
2:55	85.00		1.14	|	- /89		|
2:56	86.00	106.5	1.14	V			|
2:58	88.00		1.14	gasifier			|
2:59	89.00	109.5	1.00	|			|
3:02	92.00		1.00	|	- /87		|
3:05	95.00		1.00	|			|
3:06:3	96.50	117.0	1.14	|			|
3:09	99.00		1.14	|	- /89		|
3:15	105.00	126.5	1.14	|			|
3:19	109.00		1.14	|	- /88.5		|
3:21	111.00	133.5	1.20	|			|
3:26	116.00		1.20	|	- /89		|
3:27	117.00	140.0	1.20	|			|
3:31	121.00		1.20	|			|
3:33	123.00	148.0	1.20	|	- /87		|
3:44	134.00		1.20	V	- /88		|
3:45:0	135.13	162.5	(water & furnaces off)				|
4:01	151.00						|
4:05	155.00		(helium off)		77/82		V

Run #3: Cellulose @ 700 F

Note: carrier gas (helium) flow @ 100 scc/min



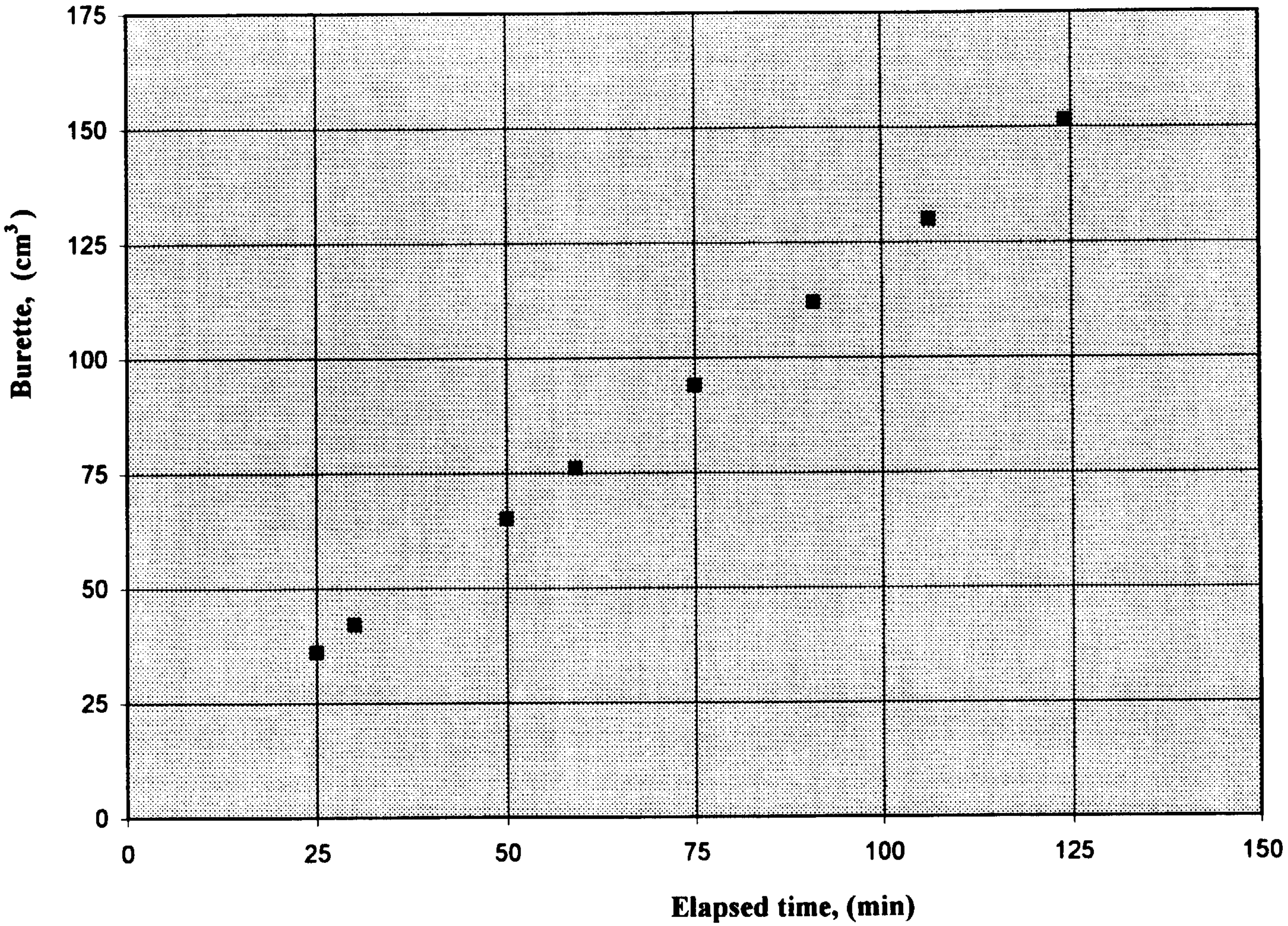
Run #3a; Cellulose Char @ 1200°F - Feb 7, 1996

Gasified carbon mass: 0.71 grams (236.45 millimoles)

Time	Elapsed Tim of Test (minutes)	Water Flow In Burrette Reading (cm^3)	(cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	flow (scc/min	Gaseous Effluents Recovered <------------ (millimoles / min) ------------> H_2	O_2	N_2	CO	CH_4	CO_2	
								mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
1:31	0.00		furnaces on		- /90	(0:53.5)/3	112.15							
1:33	2.00					34	|							
1:35	4.00						|							
1:42	11.00				- /90	30.5	|							
1:55	24.00						|							
1:56	25.00	36.0		gasifier			|							
2:00	29.00		water flow in				|							
2:01	30.00	42.0	1.15	|	- /90	34	|							
2:09:3	38.50		1.15	|			|				-	-	-	Bag sam
2:11	40.00		1.15	|	- /90	33	|							
2:21	50.00	65.0	1.19	|	- /89.5	34	|							
2:30	59.00		1.19	|	- /89	31	|							
2:30:1	59.25	76.0	1.14	|			|							
2:32:3	61.58		1.14	|			112.15				0.0188	0.0642	0.0454	
2:46	75.00	94.0	1.13	|	- /89	31	112.15				0.0060	0.0160	0.0238	Bag sam
3:01	90.00		1.13	|	- /89	33	|							
3:01:5	90.87	112.0	1.16	|			|							
3:16	105.00		1.16	|	- /89	33	112.15				0.0096	0.0174	0.0472	
3:17:2	106.33	130.0	1.19	|			|							
3:28	117.00		1.19	|	- /88.5	30.5	|							
3:35	124.00		1.19	V			112.15				0.0064	0.0183	0.1100	Bag sam
3:35:2	124.33	151.5	1.19				V							
		general shutdown												

Run #3a: Steam Gasification of Cellulose Char @ 1200°F

Note: carrier gas (helium) flow @ 112 scc/min



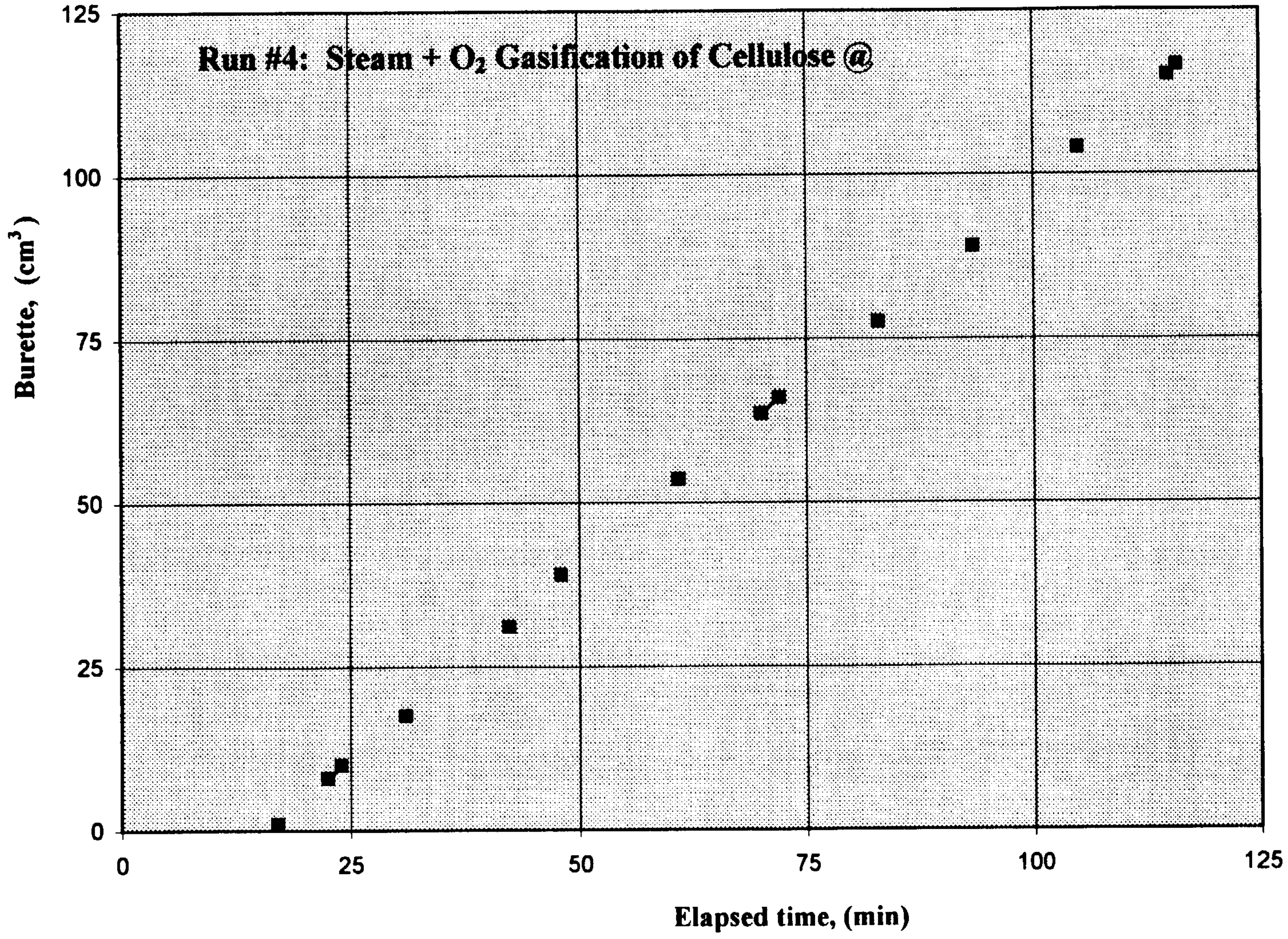
Run #4; O_2 Enriched Reformation of Cellulose @ 1200°F - Feb 9, 1996

Gasified cellulose mass: 5.22 grams (772.7 milliequivs)

Time	Elapsed Time	Water Flow In		Flow	Pressure	Helium Flow		<—— Oxygen Flow ——>			Gaseous Effluents Recovered							
	of Test	Burrette Reading		Circuit	P_3/P_5	Rotameter	flow	Rotameter	flow	mequiv/	<——— (millimoles / min) ——— HIDE							
	(minutes)	(cm^3)	(cc/min)	Sampled	(psig)	Reading	(scc/min)	Reading	(scc/min)	min	H_2	O_2	N_2	CO	CH_4	CO_2	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	%	mmols min	
1:48	0.00		furnaces on		- /90	(1:06.0)/33	90.91											
1:55	7.00				- /90	33.5	93.98	-										
2:02	14.00						|											
2:02:30	14.50					34	97.05	-										
2:05	17.00	1.0					|											
2:10	22.00				- /90	34	|	-										
2:10:30	22.50	8.0					|											
2:12	24.00	10.0	water in to	reformer			|											
2:17	29.00		1.07	|	- /90	34	|	-										
2:19	31.00	17.5	1.20	V			|											
2:22	34.00		oxygen flow on		- /90	34	|	40.0	174	28.42								
2:22	34.00		**GC (T2 = approx 300°C)**				|				?	0.3645	-	0.3038	0.4314	16.6	1.0085	Reformer
2:25	37.00		1.20	|			|											
2:25:44	37.73		switch flow to gasifier				|											
2:29	41.00		1.20	|	- /90	34	|	38.5	162	26.48								
2:30:16	42.27	31.0	1.20	|			|											
2:31:45	43.75		**Bag (T2 = 640°C)**				|			27.37	?	0.2192	0.2248	0.2192	0.0787	16.2	0.9103	Gasifier
2:35	47.00		1.20	|	- /89	34	|	40.0	174	28.42								
2:36	48.00	39.0	1.20	|			|											
2:39	51.00		1.20	|			|											
2:49	61.00	53.5	1.14	|	- /90	34	V	39.0	166	27.13								
2:35	47.00		1.14	V	- /89	33	90.91											
2:53:30	65.50		**GC (T2 = approx 630°C)**				94.16			26.85		2.8611	0.0000	1.3590	0.0143	4.80	0.0572	Gasifier
2:58	70.00	63.5	1.14	|			|										
3:00	72.00	66.0	switch flow to reformer				V											
3:06:30	78.50		**Bag (T2 = approx 630°C)**				96.44			26.05	?	0.9308	0.9582	0.2738	0.0411	10.2	0.6981	Gas/Refor
3:10	82.00		1.07	|	- /89	34	97.05	38.0	158	25.84								
3:11	83.00	77.5	1.07	|														
3:21	93.00		1.07	|	- /89	34.5	100.12	39.0	166	27.13								
3:21:30	93.50	89.0	1.21	V			|											
3:27:20	99.33		**GC (T2 = approx 630°C)**				|				-	2.8772	-	-	-	3.10	0.2230	Gas/Refor
3:28	100.00		switch flow to gasifier				V											
3:32	104.00		1.21	|	- /89	34.5	100.12	38.0	158	25.84								
3:33	105.00	104.0	1.21	|														
3:34:45	106.75		**Bag (T2 = 630-640°C)**				100.97				-	-	-	-	-	0.10	0.0041	Gasifier
3:42	114.00		1.21	|	- /89	35	103.20	39.0	166	27.13								
3:43	115.00	115.0	1.21	V														
3:44	116.00	116.5	shut down water & furnaces															
4:43	175.00		general shutdown															

Run #4: Steam + O_2 Gasification of Cellulose @ 1200°F

Note: carrier gas (helium) flow @ 112 scc/min



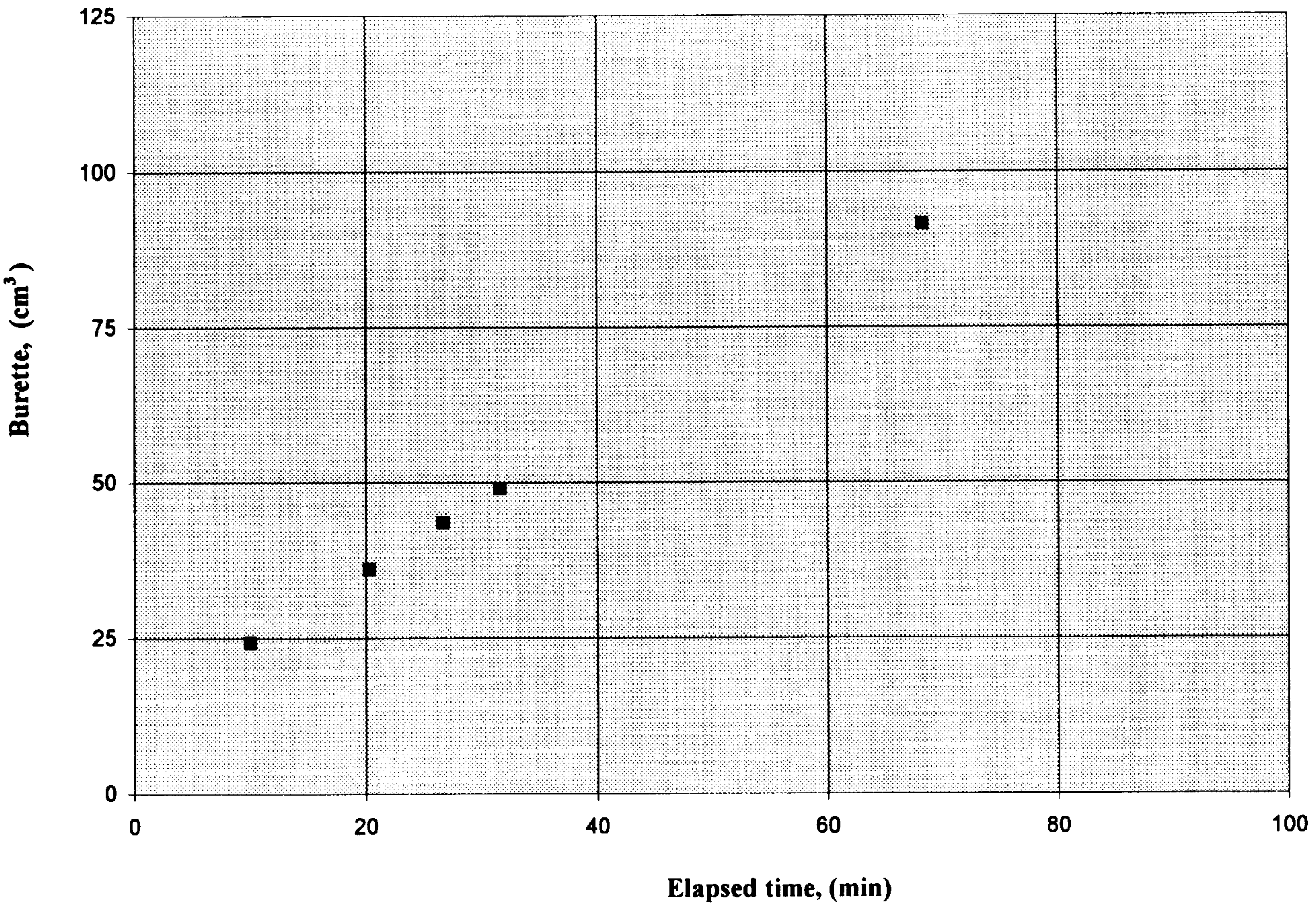
Run #5; O_2 Enriched Reformation of Cellulose @ 1400°F - Feb 14, 1996

Gasified cellulose mass: 5.81 grams (**860.0** milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm³)	Water Flow In Burrette Reading (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<—— Oxygen Flow ——> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/min	Gaseous Effluents Recovered <———— (millimoles / min) ————> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
1:43	-2.00	16.0															
1:45	0.00		furnaces on														
1:46	1.00							-									
1:50:50	5.83				90/90	39.5	131.61	13.0	54.56	8.921							
1:55	10.00	24.2	water in to gasifier														
1:59	14.00		1.14	|	89/89	40	133.63	13.0	54.03	8.835							
2:05	20.00		1.14	|	89/89	40	133.63	13.0	54.03	8.835							
2:05:20	20.33	36.0	1.18	V				-									
2:08:25	23.42		**GC (T2 = 200°C)**									3.0802	-	-	-	1.7249	Gasifier
2:09	24.00		1.18		98.5/90.5	40	134.91	13.0	54.82	8.963							
2:10	25.00		switch flow to reformer														
2:11:40	26.67	43.5	1.12		99/89												
2:15:30	30.50		**Bag (T2 = 300-500°C)**			40	134.91	13.5	55.84	9.131	0.6898	0.2725	0.0612	0.0819	0.0190	1.9832	Reformer
2:16:35	31.58	49.0	1.12	|													
2:30	45.00		1.16	|	- /90												
2:33	48.00		1.16	|	117/84	40.5	130.34	15.0	56.49	9.237							
2:37:30	52.50		1.16	|	- /49.5		|										
2:40	55.00		1.16	|	- /39.5		|										
2:42	57.00		1.16	|	- /29		|										
2:47	62.00		1.16	V	- /21		|										
2:48:30	63.50		**GC (T2 = 700°C)**				|				0.5844	0.5163	1.1689	0.1851	0.3214	1.6364	Reformer
2:53:20	68.33	91.5	1.16		- /15	100	V	47.0	63.51	10.384							
3:03	78.00	101.6	Water flow off - Shut down														

Run #5: Steam + O_2 Gasification of Cellulose @ 1400°F

Note: carrier gas (helium) flow @ 132 scc/min



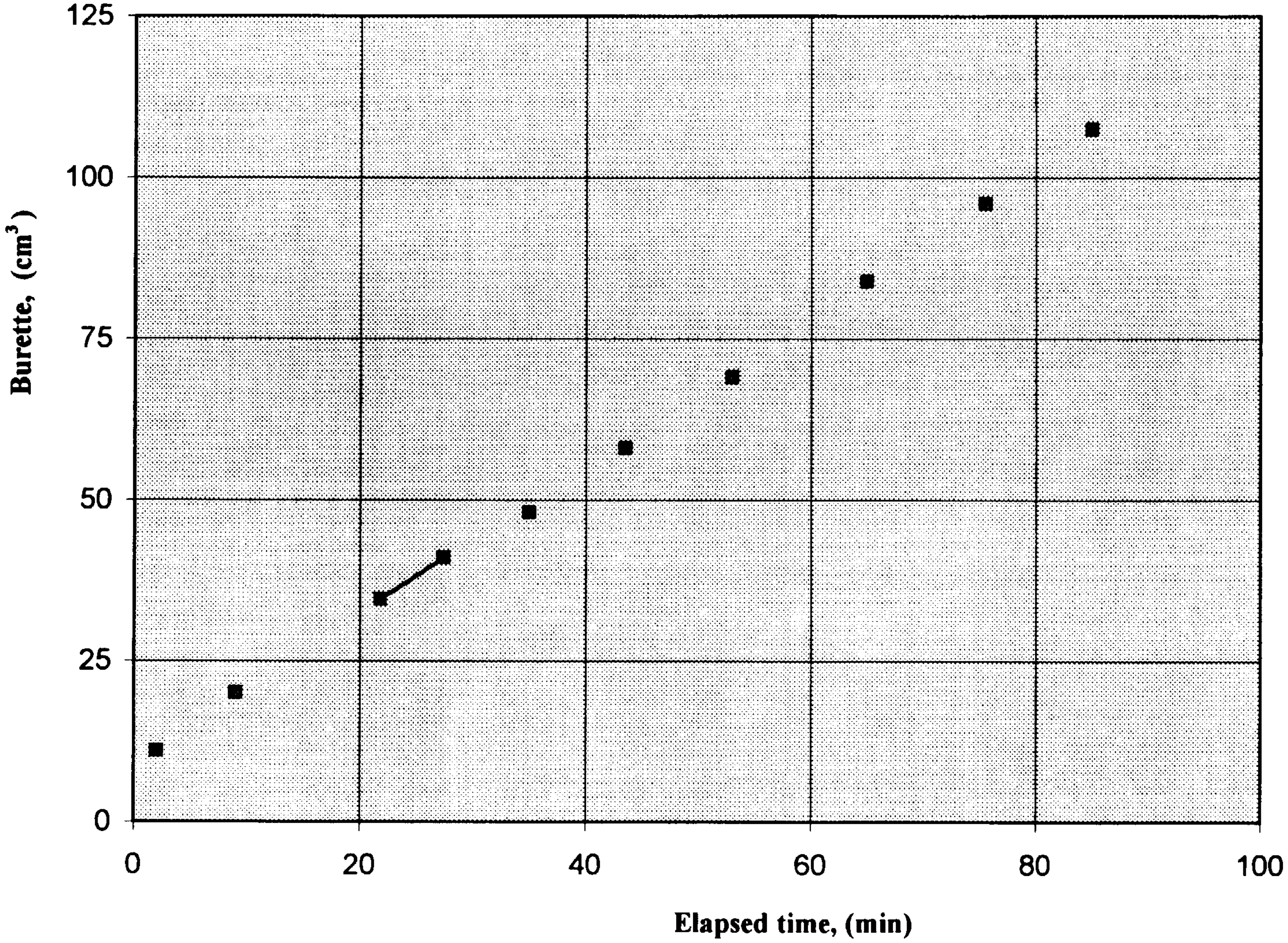
Run #6; O_2 Enriched Reformation of Urea @ 1400°F - Feb 27, 1996

Gasified urea mass: 10.45 grams 1044.04 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	Water Flow In (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<------ Oxygen Flow ------> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/ min	Gaseous Effluents Recovered <-------------- (millimoles / min) --------------> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
9:30	0.00		furnaces on		98/90	39.5	131.61	10.0	47.58	7.780							
9:32	2.00	11.0	1.29		- /91	40	136.20	10.0	48.03	7.854							
9:34	4.00		1.29														
9:38	8.00		1.29														
9:39	9.00	20.0	water in to gasifier														
9:41	11.00		1.14		89/89	40	133.63	9.5	46.10	7.537							
9:44	14.00	(22.3)	**GC (T2 = approx 100°C)**			40	133.63	13.0	54.03	8.835		3.9798	-	-	-	0.5074	Reformer
9:47	17.00		switch flow to gasifier														
9:51:50	21.83	34.5	**Bag (T2 = 250-300°C)**			40	134.91	9.0	45.54	7.446		0.8497	1.3300	0.0055	-	0.4803	Gasifier
9:57:25	27.42	41.0	0.92		98/90	40	134.91	9.0	45.54	7.446							
10:02:50	32.83		**Bag (T2 = 500-550°C)**									0.8351	1.2147	0.0243	0.0061	0.0493	Reformer
10:03	33.00		0.92	|	99/89	40	133.63	8.5	44.15	7.219							
10:05	35.00	48.0	1.18	V													
10:12:30	42.50		**Bag (T2 = 600-650°C)**									1.1918	1.1918	0.0064	0.0064	0.0604	Gasifier
10:13:30	43.50	58.0	1.16		98/88	40	132.34	8.0	42.81	7.000							
10:18:10	48.17		**GC (T2 = approx 640°C)**									1.6927	0.0736	0.0103	0.0059	0.0883	Reformer
10:22	52.00		1.16	|	99/89.5	40	134.27	9.5	46.32	7.574							
10:23	53.00	69.0	1.23	V													
10:24	54.00		switch flow to gasifier														
10:31	61.00		1.23	|	98/88	40	132.34	9.8	46.26	7.564							
10:35	65.00	83.8	1.16	|													
10:40	70.00		1.16	|													
10:43	73.00		1.16	|	98/86	40	129.76	10.0	45.76	7.482							
10:45:30	75.50	96.0	1.21	|													
10:51	81.00		1.21	V	98/85	40.5	131.66	14.0	54.44	8.901							
10:55	85.00	107.5	**GC (T2 = approx 750°C)**									2.1345	-	-	-	-	Gasifier
10:57	87.00		shut down O2														
11:01	91.00		1.12		98/86	40	129.76	12.0	50.10	8.191							
11:20	110.00	135.4	shut off water														
11:21	111.00		shut down furnaces														
1:00	210.00		Helium flow off														

Run #6: Steam + O_2 Gasification of Urea @ 1400°F

Note: carrier gas (helium) flow @ 132 scc/min



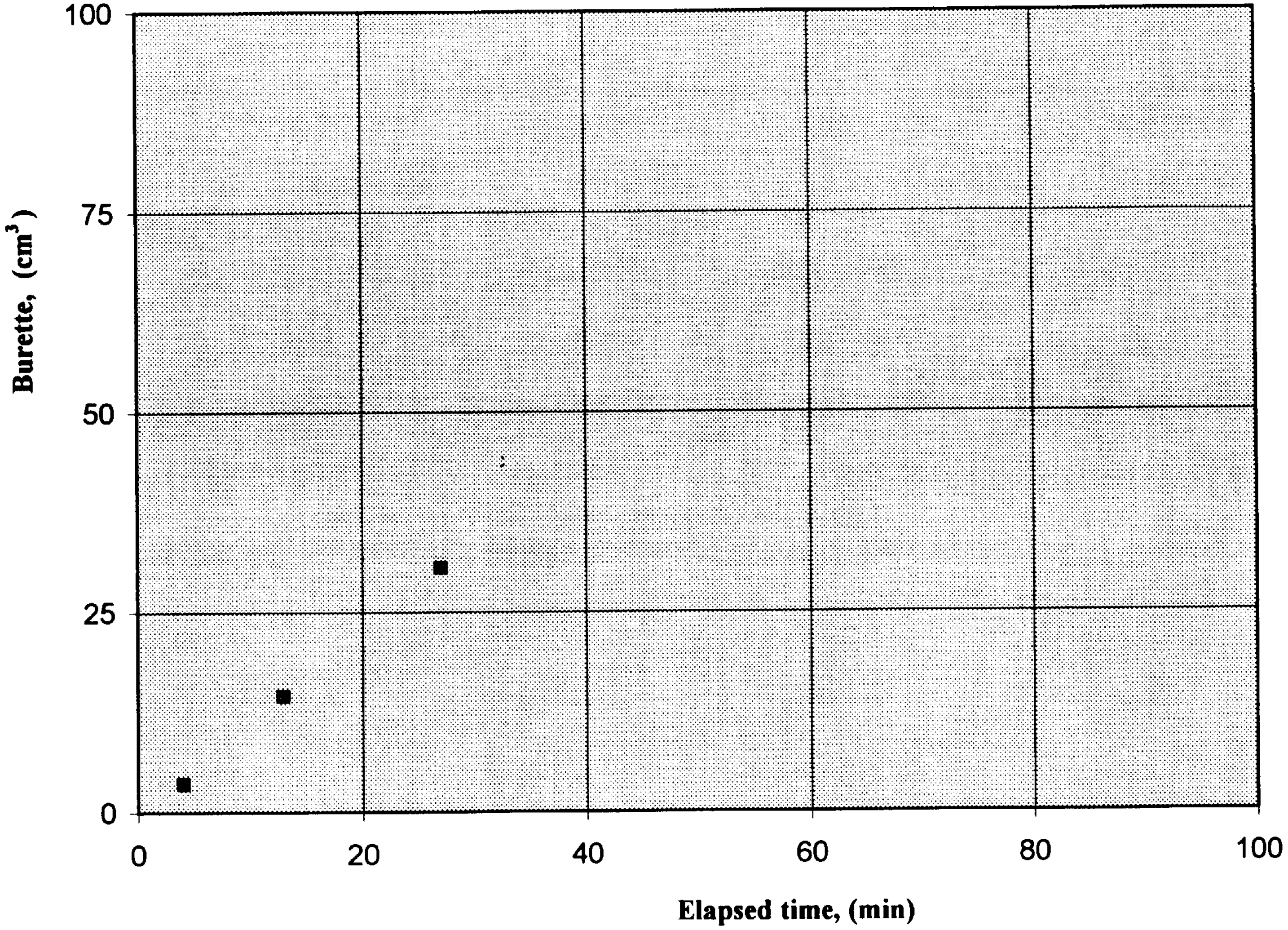
Run #7; O_2 Enriched Reformation of Urea @ 1400°F - Feb 28, 1996

Gasified urea mass: 9.99 grams (998.1 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	Water Flow In Burrette Reading (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<---- Oxygen Flow ----> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/ min	Gaseous Effluents Recovered <------ (millimoles / min) ------> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
2:37	0.00				98/90	40	134.91	3.5	36.89	6.032							
2:40	3.00		furnaces on														
2:41	4.00	3.5	1.10														
2:44	7.00		1.10		99/91	40	136.20	3.5	37.24	6.090							
2:50	13.00	14.5	water in to reformer														
2:51:3	14.50		1.14	V	99/91	40	136.20	3.0	36.67	5.995							
2:55	18.00		**GC (T2 = approx 160°C)**									1.7687	-	-	-	0.3537	Reformer
3:00	23.00		1.14	|	98/90												
3:04	27.00	30.5	1.14	V													
			aborted run due to plugging														

Run #7: Steam + O_2 Gasification of Urea @ 1400°F

Note: carrier gas (helium) flow @ 132 scc/min



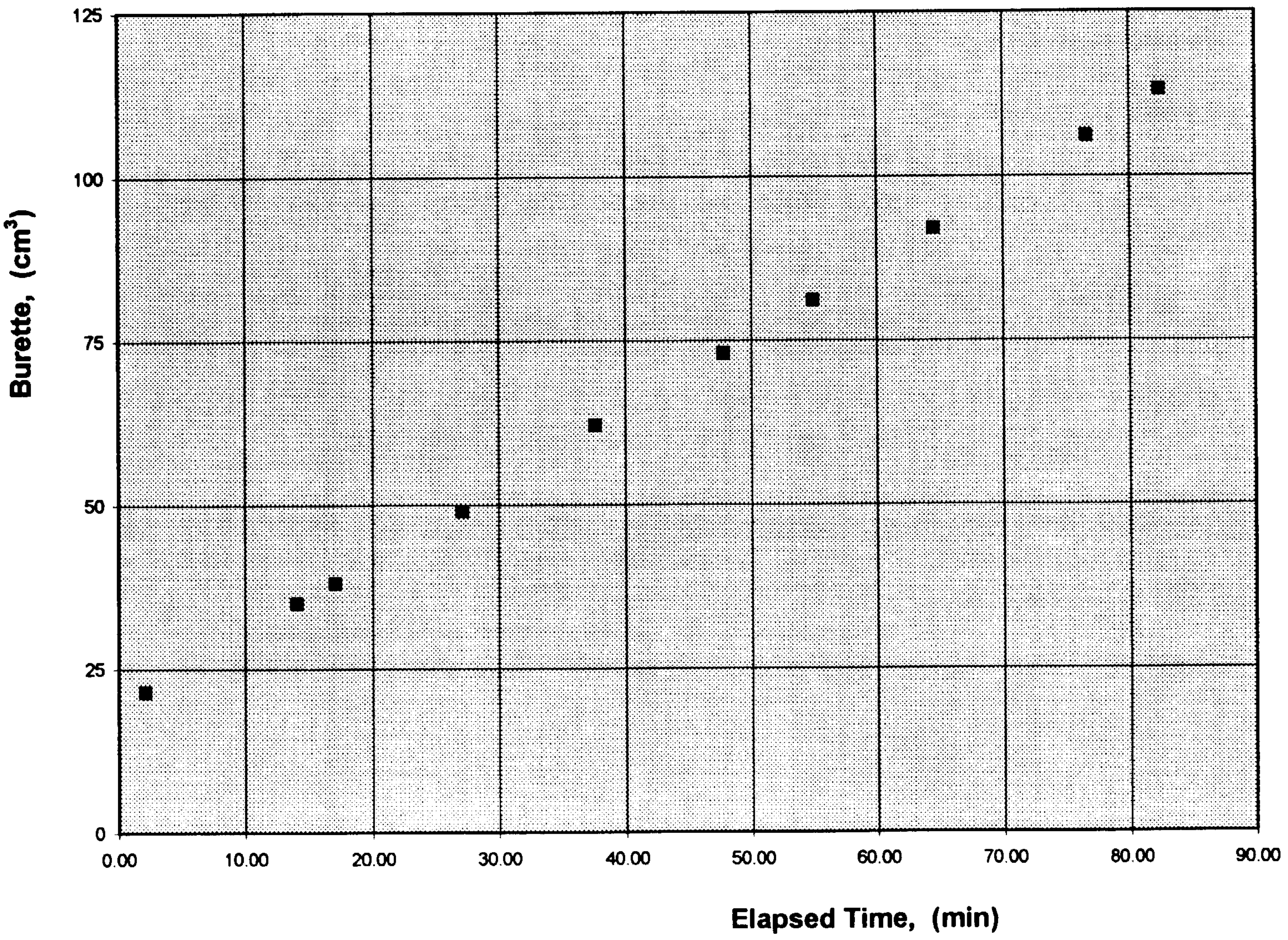
Run #8; O_2 Enriched Steam Reformation of IGEPON TC-42 @ 1400°F - March 1, 1996

Gasified Igepon TC-42 mass: 6.54 grams 479.6 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette (cm^3)	Reading (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	flow (scc/min)	<------ Oxygen Flow ------> Rotameter Reading	flow (scc/min)	mequiv/ min	Gaseous Effluents Recovered <------ (millimoles / min) ------> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
3:10	0.00		furnaces on														
3:11	1.00				91/83	40.5	129.02	6.5	38.32	6.266							
3:12:08	2.13	21.5	1.13														
3:21	11.00		1.13														
3:24:05	14.08	35.0	water in to gasifier														
3:27:04	17.07	38.0	1.07		97/89	37.5	117.75	14.0	56.62	9.258							
3:33	23.00		1.07		96/86	40.5	132.99	13.5	53.71	8.782							
3:37:07	27.12	49.0	**GC (T2 = approx 400°C)**								0.0007	0.7232	0.0263	0.0375	0.0421	0.3090	Gasifier
3:37:30	27.50		switch to reformer effluent														
3:40:45	30.75		1.23		96/87	41	137.61	14.0	55.53	9.080							
3:47	37.00		**Bag (T2 = 550-600°C)**								-	0.0595	0.3675	0.0214	0.2339	0.3742	Reformer
3:47:40	37.67	62.0	1.09		92/89	40.5	136.95	14.0	56.62	9.258							
3:50	40.00		switch to gasifier effluent														
3:52	42.00		1.09		90/88	41	138.97	14.0	56.08	9.169							
3:57:45	47.75	73.0	1.12		95/93	40	138.78	14.0	58.81	9.616							
3:58:15	48.25		**Bag (T2 = 650-660°C)**								-	0.8074	0.6777	0.0043	0.0058	0.0411	Gasifier
4:01:20	51.33		switch to reformer effluent														
4:04:54	54.90	81.0	1.15		91/87	40.5	134.31	14.0	55.53	9.080							
4:09	59.00		**GC (T2 = 710°C)**								-	0.9826	0.0242	0.0026	0.0138	0.0373	Reformer
4:14:30	64.50	92.0	1.17		94/92	40	137.49	14.0	58.26	9.526							
4:17:20	67.33		O2 bottle shut off														
4:26:36	76.60	106.0	1.17		93/90	40.5	138.27	14.0	57.17	9.348							
4:32:25	82.42	113.0	end run - system shut down														

Run #8: Steam + O2 Gasification of Igepon TC-42 @ 1400oF

Note: carrier gas (helium) flow = 132 scc/min



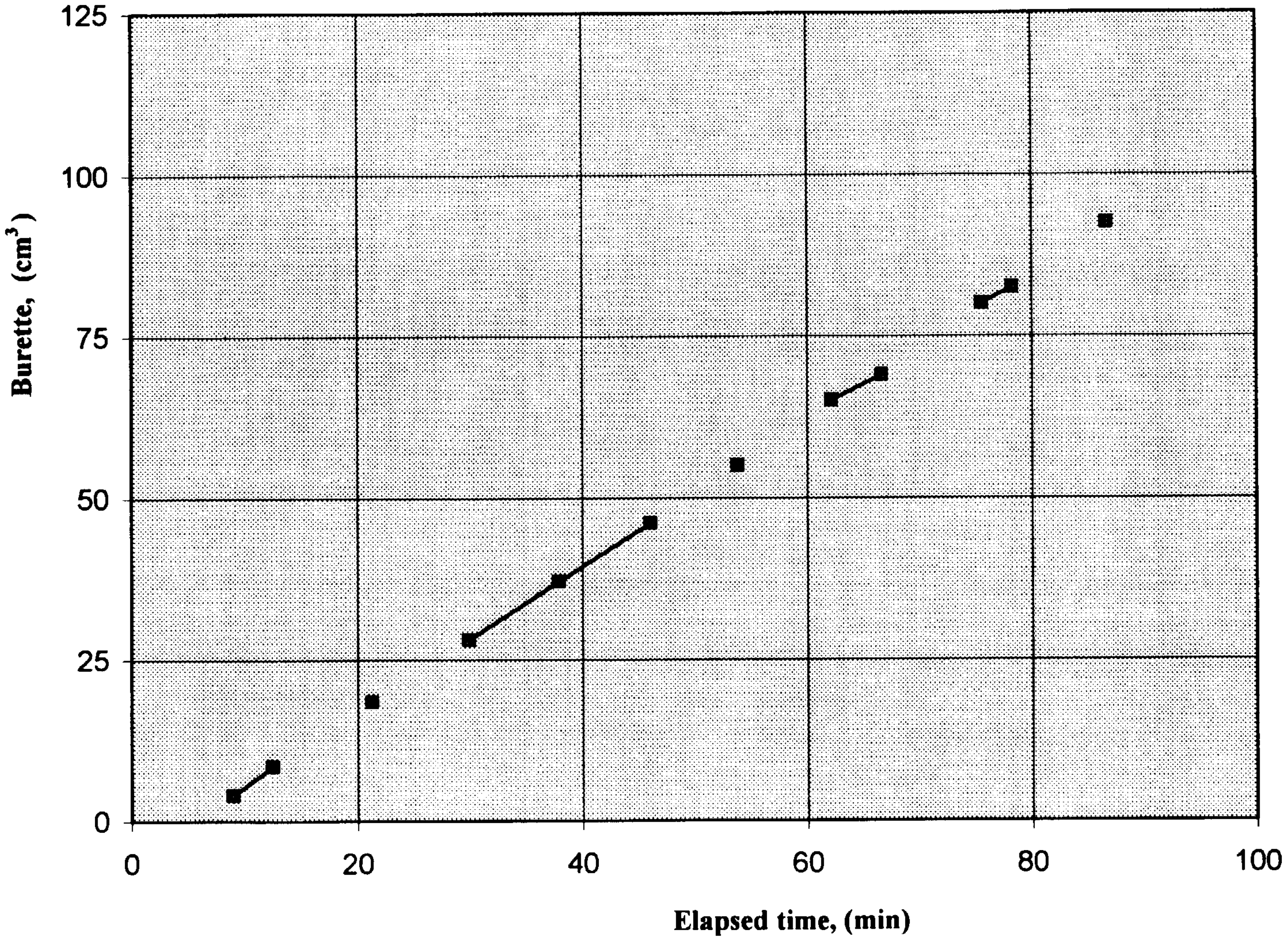
Run #9; O_2 Enriched Reformation of Wheat Straw @ 1400°F - March 4, 1996

Gasified Wheat Straw mass: 3.58 grams (435.6 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette (cm³)	Water Flow In Reading (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<—— Oxygen Flow ——> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/ min	Gaseous Effluents Recovered <———— (millimoles / min) ————> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
3:20	0.00		furnaces on														
3:29	9.00	4.0	water in; "ice bath" @ 35.8°C														
3:32:30	12.50	8.5	1.14		100/94	40.5	143.55	14.5	60.76	9.936							
3:35	15.00		**GC (T2 = approx 350°C)**				138.41					1.7860	-	0.0149	-	0.1786	Reformer
3:37	17.00		1.14		98/87	40.5	134.31	14.5	56.85	9.296							
3:41:15	21.25	18.5	1.12		98/89	40	133.63	14.5	57.97	9.479							
3:44:45	24.75		**Bag (T2 = approx 520°C)**				133.63				-	0.1774	0.5840	0.0293	0.0505	0.5185	Reformer
3:49:50	29.83	28.0	1.12		100/89	40	133.63	14.0	56.62	9.258							
3:57:56	37.93	37.0	1.12		99/87	40	131.05	14.0	55.53	9.080							
4:06:03	46.05	46.0	"ice bath" @ 36.7°C		99/85	38	116.17	14.0	54.44	8.901							
4:07	47.00		**GC (T2 = 720-730°C)**				118.48					0.3935	0.0057	0.0013	-	0.5394	Reformer
4:07:40	47.67		switch flow to gasifier														
4:13:46	53.77	55.0	1.08		96/90	40	134.91	14.0	57.17	9.348							
4:19	59.00		**Bag (T2 = 730-740°C)**				132.26					0.7246	1.1578	0.0015	0.0373	0.1419	Gasifier
4:21:30	61.50		switch flow to reformer														
4:22:10	62.17	65.0	V	|													
4:26:42	66.70	69.0	1.18	V	99/90	39	128.36	14.0	57.17	9.348							
4:31:30	71.50		**Bag (T2 = 740°C)**				132.47					0.9597	1.2224	-	-	0.0190	Reformer
4:34:30	74.50		switch flow to gasifier														
4:35:34	75.57	80.0	|	|													
4:38:15	78.25	82.5	V	V	94/90	40.5	138.27	14.0	57.17	9.348							
4:40	80.00		**GC (T2 = 740-745°C)**				141.81					1.3616	-	0.0014	-	0.0300	Gasifier
4:44	84.00	(89.3)	shut down oxygen flow														
4:46:42	86.70	92.5	1.18		36/85	44	155.36	-	0.00	0.000							
4:46:42	86.70		end run - system shut down														

Run #9: Steam + O_2 Gasification of Wheat Straw @ 1400°F

Note: carrier gas (helium) flow @ 132 scc/min



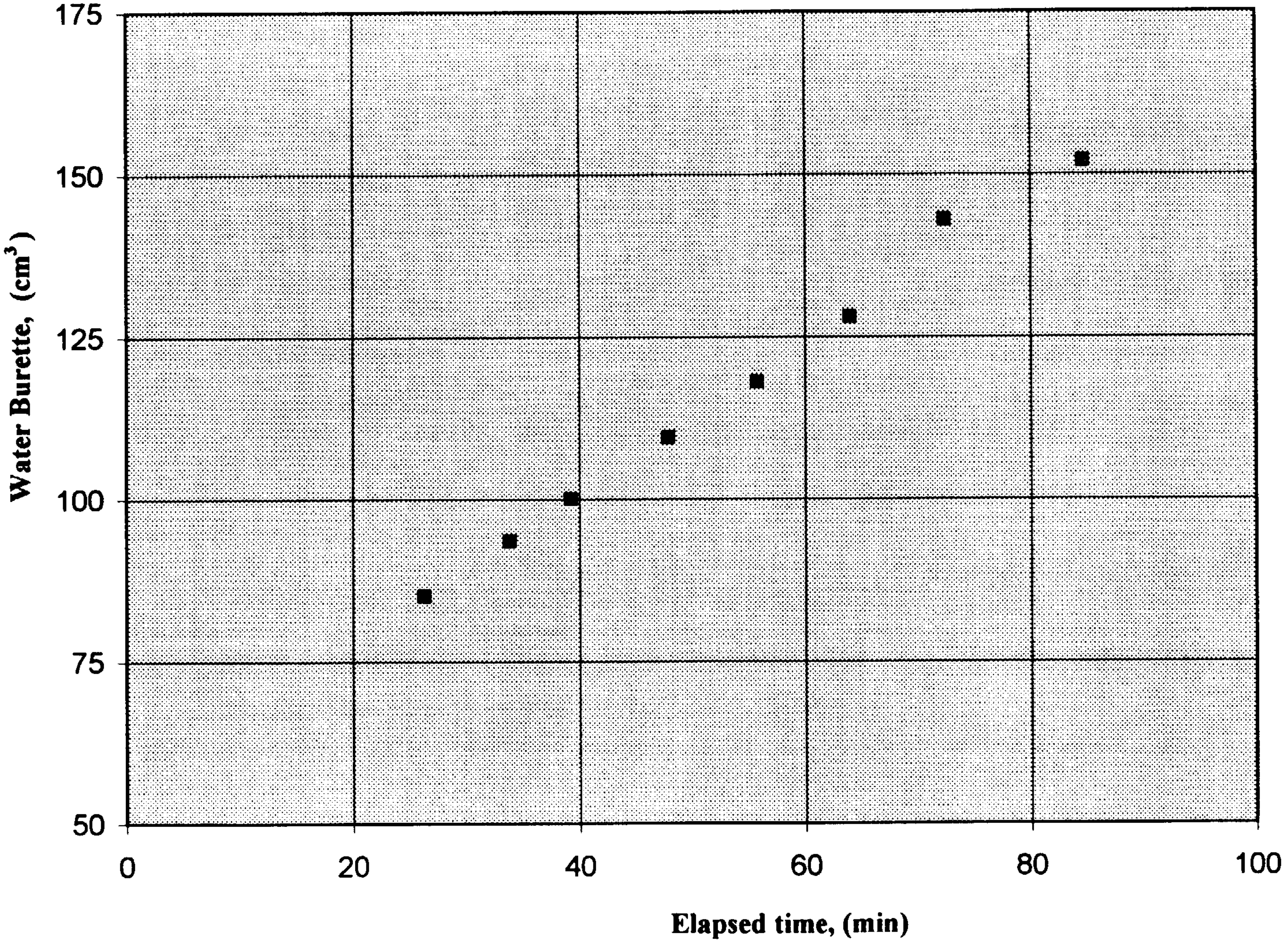
Run #10; O_2 Enriched Reformation of IGEPON TC-42 @ 1600°F - March 6, 1996

Gasified Igepon TC-42 mass: 8.66 grams (635.1 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In		Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow		<—— Oxygen Flow ——>			Gaseous Effluents Recovered <———— (millimoles / min) ————>						
		Burrette Reading (cm^3)	(cc/min)			Rotameter Reading	flow (scc/min)	Rotameter Reading	flow (scc/min)	mequiv/ min	H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
3:43	0.00		all furnaces on														
3:47	4.00	59.0			108/93.	38	126.07	16.5	66.48	10.870							
3:52:25	9.42	65.5			100/90	40	134.91	19.0	72.39	11.836							
3:55:10	12.17		water flow cut in														
4:01:35	18.58	76.0	1.15		102/90	39	128.36	15.5	61.36	10.033							
4:02	19.00		**GC (T2 = 180-200°C)**				128.62					1.0092	0.1581	0.0545	0.0262	0.2220	Reformer
4:09:14	26.23	85.0	1.15		106/94	39	133.26	18	71.69	11.723							
4:11:22	28.37		**Bag (T2 = approx 500°C)**				132.28				-	0.2753	0.9740	0.0198	0.0572	0.3247	Reformer
4:13:22	30.37		switch flow to gasifier														
4:16:50	33.83	93.5	1.20		100/86	40	129.76	19.0	69.62	11.384							
4:21	38.00		**Bag (T2 = 600-650°C)**				138.34					0.4890	0.8414	0.0093	0.0245	0.1726	Gasifier
4:22:15	39.25	100.0	1.10		104/92	40.5	140.91	19.0	73.77	12.062							
4:22:30	39.50		switch flow back to reformer														
4:30:52	47.87	109.5	1.08		104/91	40	136.20	18.0	69.71	11.399							
4:33:30	50.50		**GC (T2 = 680-700°C)**				136.20					0.8012	0.0120	0.0087	0.0668	0.2203	Reformer
4:38:45	55.75	118.0	1.21		104/91	40	136.20	18.0	69.71	11.399							
4:42:23	59.38		**Bag (T2 = 700-720°C)**				139.21					0.8897	0.7711	0.0015	0.0059	0.0556	Reformer
4:47	64.00	128.0	1.16		104/91	41	143.03	19.0	73.08	11.949							
4:48	65.00		start shutdown: O2 bottle off														
4:55:27	72.45	143.0	1.16		104/92	39	130.81	16.5	65.56	10.719							
4:59	76.00		switch flow to gasifier														
5:07:40	84.67	152.0	1.16		102/89.	39	127.74	16.0	62.52	10.224							
5:08	85.00		**GC (T2 = approx 750°C)**				127.66					1.5608	-	0.0014	-	0.0054	Gasifier
5:13	90.00		end run - system shut down														

Run #10: Steam + O_2 Reformation of IGEPON TC-42 @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



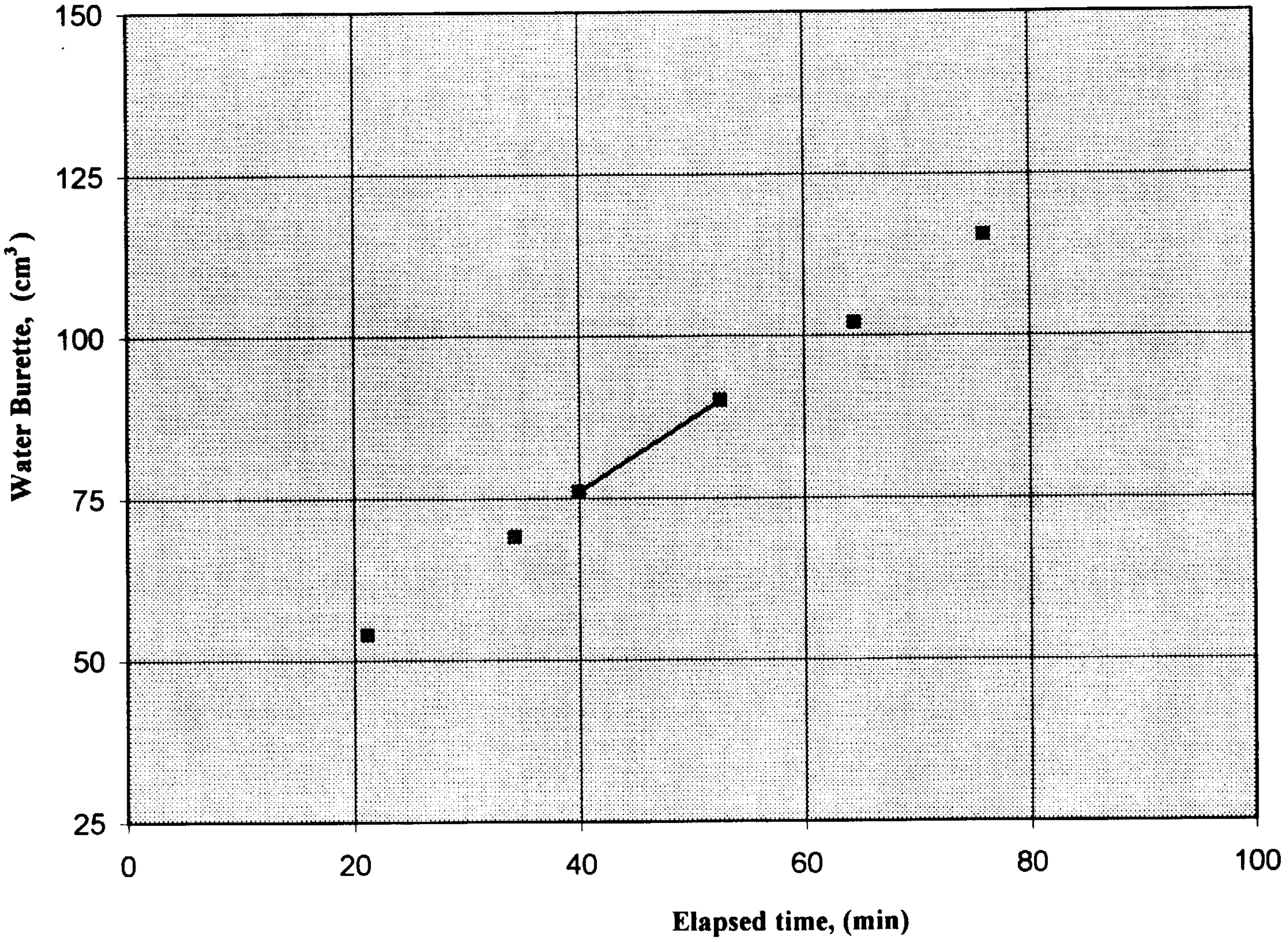
Run #11; O_2 Enriched Reformation of IGEPON TC-42 @ 1600°F - March 8, 1996

Gasified Igepon TC-42 mass: 8.45 grams (619.7 milliequivs)

Time	Elapsed Time of Test	Water Flow In Burrette Reading		Flow Circuit	Pressure	Helium Flow		<------ Oxygen Flow ------>			Gaseous Effluents Recovered <--------------- (millimoles / min) --------------->						
	(minutes)	(cm³)	(cc/min)	Sampled	P_3/P_5 (psig)	Rotameter Reading	flow (scc/min)	Rotameter Reading	flow (scc/min)	mequiv/ min	H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
			all furnaces approx 1 hr preheat														
2:07	0.00		water flow cut in														
2:08:45	1.75	32.0	1.05		102/88	40	132.34	16	61.62	10.076							
2:13:20	6.33	37.0	1.05		102/87	40	131.05	14	55.53	9.080							
2:18:45	11.75	42.5	1.22		105/90	38	122.00	14	57.17	9.348							
2:21	14.00		**Bag (T2 = 200-300°C)**				121.39				-	0.1352	0.6578	0.0049	0.1107	0.2766	Reformer
2:28:10	21.17	54.0	1.15		107/90.5	37.5	119.46	14	57.44	9.392							
2:28:12	21.20		**Bag (T2 = 500-600°C)**				119.48				-	0.0901	0.3819	0.0180	0.2642	0.3663	Reformer
2:29:45	22.75		switch flow to gasifier									15					
2:35:50	28.83		**Bag (T2 = 600-640°C)**				123.95					3.12 *	12.5 *	0.0042	-	0.1247	Gasifier
2:41:15	34.25	69.0	1.22		104/89	39	127.13	14.0	56.62	9.258							
2:42	35.00		**GC (T2 = approx 650°C)**				126.87				-	0.0042	0.0066	0.0300	0.2040	0.5701	Reformer
2:47	40.00	76.0	1.15		103/90	38.5	125.15	14.0	57.17	9.348							
2:59:30	52.50	90.0	* system plugged		* 112 /70	26	49.17	6.0	32.59	5.329							
3:06:30	59.50		switch to gasifier - solves plug problem														
3:11:30	64.50	102.0	1.17		100/88	40	132.34	16.0	61.62	10.076							
3:15	68.00		**GC (T2 = 740°C)**				130.74					0.27 *	1.08 *	0.0013	0.0051	0.0480	Gasifier
3:23	76.00	115.5	1.17		100/88	40	132.34	16.0	61.62	10.076							
3:35	88.00		end run - system shut down														

Run #11: Steam + O_2 Reformation of IGEPON TC-42 @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



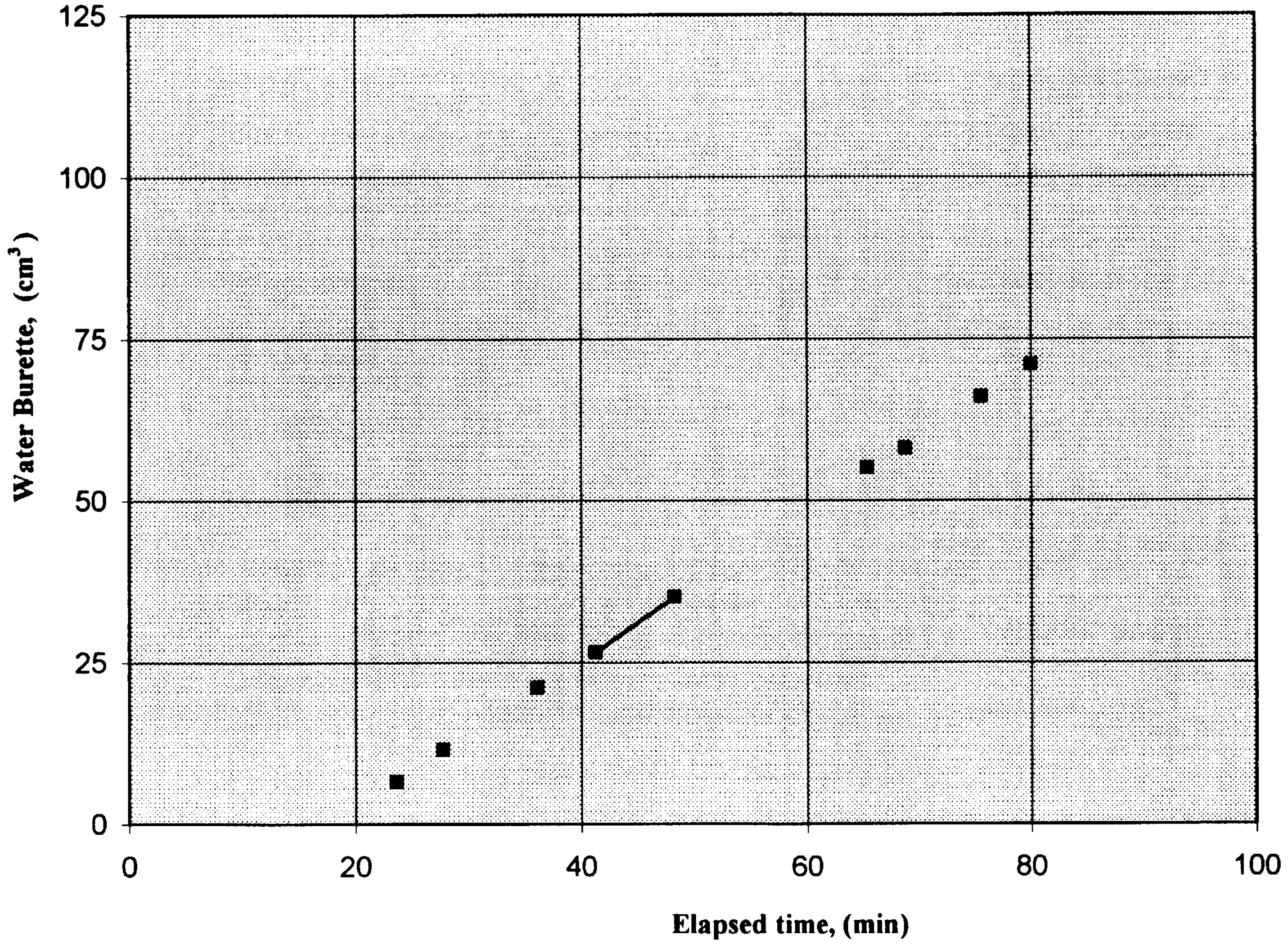
Run #12; O_2 Enriched Reformation of Polyethylene @ 1600°F - March 19, 1996

Gasified Polyethylene mass: 6.81 grams (2913.0 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	Water Flow In (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<—— Oxygen Flow ——> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/min	Gaseous Effluents Recovered <—— (millimoles / min) ——> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
2:00	0.00		bottom heaters on (top heater still off)														
2:15	15.00		1.20		102/89	40	133.63	13	54.03	8.835							
2:23:35	23.58	6.5	1.20		101/88	40	132.34	13	53.51	8.750							
2:24:20	24.33		top (gasifier) furnace on														
2:27:45	27.75	11.5	1.14		101/88	40	132.34	13	53.51	8.750							
2:28:10	28.17		water admitted to test rig														
2:34	34.00		**GC (T2 = 180°C)**				135.24					0.9661	-	-	-	0.2147	Gasifier
2:35	35.00		switch flow to reformer														
2:36:05	36.08	21.0	1.15		104/91	40	136.20	9	45.97	7.517							
2:41	41.00		**Bag (T2 = 200-250°C)**				125.72					0.5081	0.7847	-	-	-	Reformer
2:41:16	41.27	26.5	1.15		106/90	38.5	125.15	8	43.64	7.136							
2:48:14	48.23	35.0	1.16		110/85	26	57.88	4	35.71	5.838							
2:50	50.00		problems wi plugging - back pressure dropped to 55 psig														
2:56:45	56.75		**Bag (T2 = 500-600°C)**								1.0754	0.1893	0.3742	0.0129	0.0946	0.1893	Reformer
3:05:25	65.42	55.0	1.10		88/55	48	129.58	23	58.01	9.485							
3:06:20	66.33		**GC (T2 = approx 680°C)**				154.27				0.5120	0.3591	-	0.0053	-	0.4585	Reformer
3:08:50	68.83	58.0	1.10		74/53	63	221.60	30	76.62	12.528							
3:11:45	71.75		**Bag (T2 = 700-720°C)**				169.37					0.9670	1.1387	0.0009	-	0.0072	Gasifier
3:15:35	75.58	66.0	1.10		97/53	43	100.73	17	42.59	6.964							
3:16	76.00		all furnaces off														
3:20	80.00	71.0	1.10														
3:20	80.00		end run - system shut down														

Run #12: Steam + O_2 Reformation of Polyethylene @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



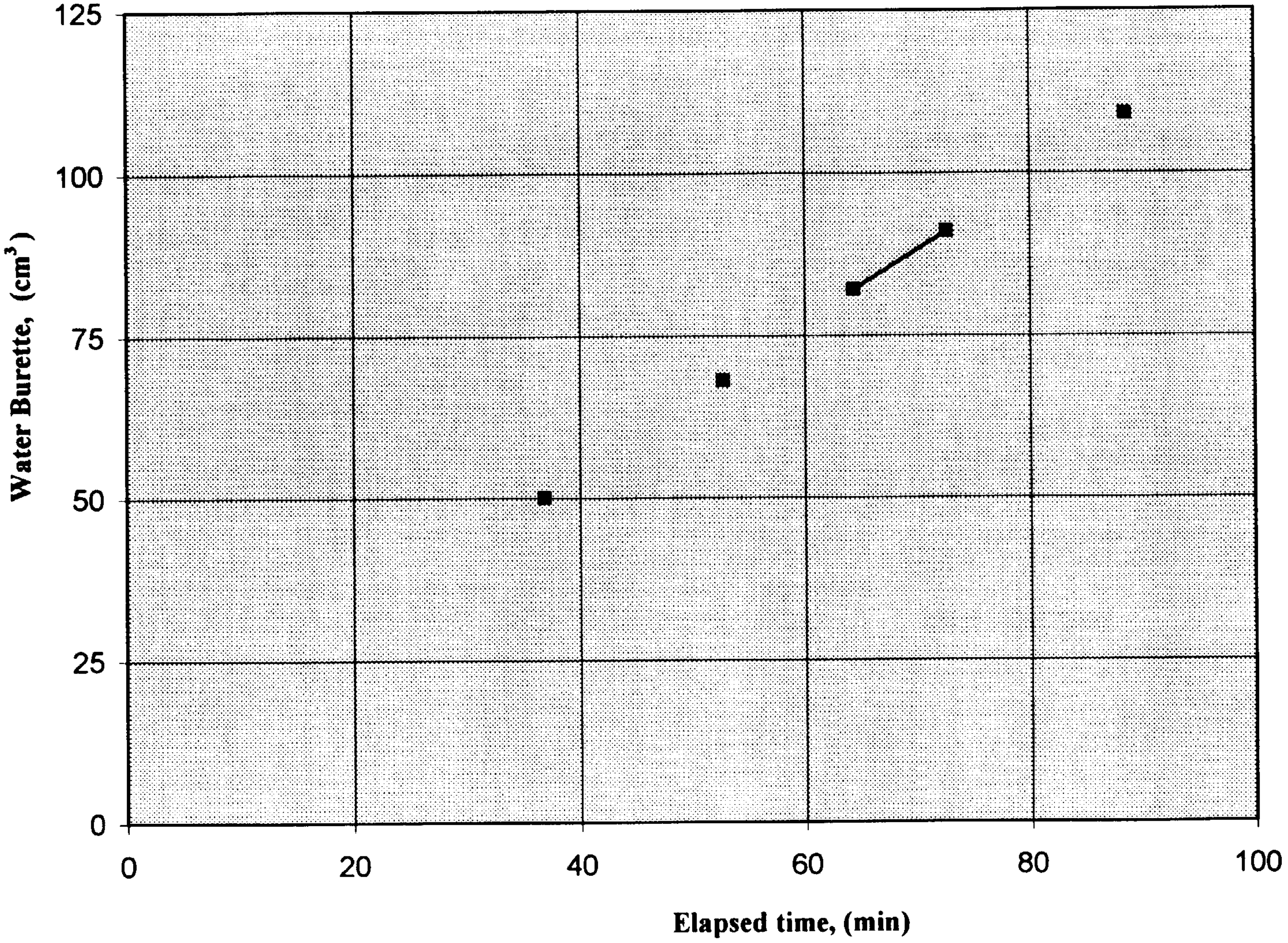
Run #13; Steam Reformation of Sugar (Sucrose) @ 1400°F - March 25, 1996

Gasified Sucrose mass: 6.62 grams (928.31 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	(cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	flow (scc/min)	<—— Oxygen Flow ——> Rotameter Reading	flow (scc/min)	mequiv/ min	Gaseous Effluents Recovered <-------------- (millimoles / min) --------------> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
1:25	0.00		bottom heaters on (top heater still off)														
1:35	10.00		noted that bottom furnace inoperative -														
1:53	28.00	40.0	1.13		97/92	38.5	127.54	-	-	-							
1:54	29.00		turn on top furnace (No. 1).														
2:01:50	36.83	50.0	1.14		98/93	38.5	128.74	-	-	-							
2:02	37.00		start water flow into rig														
2:09:15	44.25		**Bag (T2 = 156-176°C)**				77.61					0.0036	0.0303	-	-	0.0555	Gasifier
2:17:40	52.67	68.0	1.15		116/90	10	19.59	-	-	-							
2:23:10	58.17		**Bag (T2 = 278-494°C)**				16.35				0.5201	0.0023	0.0306	0.4785	0.0458	0.3349	Gasifier
2:29:25	64.42	82.0	1.15		126/81	0	12.66	-	-	-							
2:37:37	72.62	91.0	1.13		123/84	0	13.06	-	-	-							
2:44:23	79.38		**Bag (T2 = 660-704°C)**				13.16				0.0937	0.0010	0.0193	0.3497	0.1105	0.2867	Gasifier
2:53:33	88.55	109.0	1.13		116/87	0	13.46	-	-	-							
2:54	89.00		water off														
2:54:30	89.50		end run - system shut down														

Run #13: Steam Reformation of Sugar (Sucrose) @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



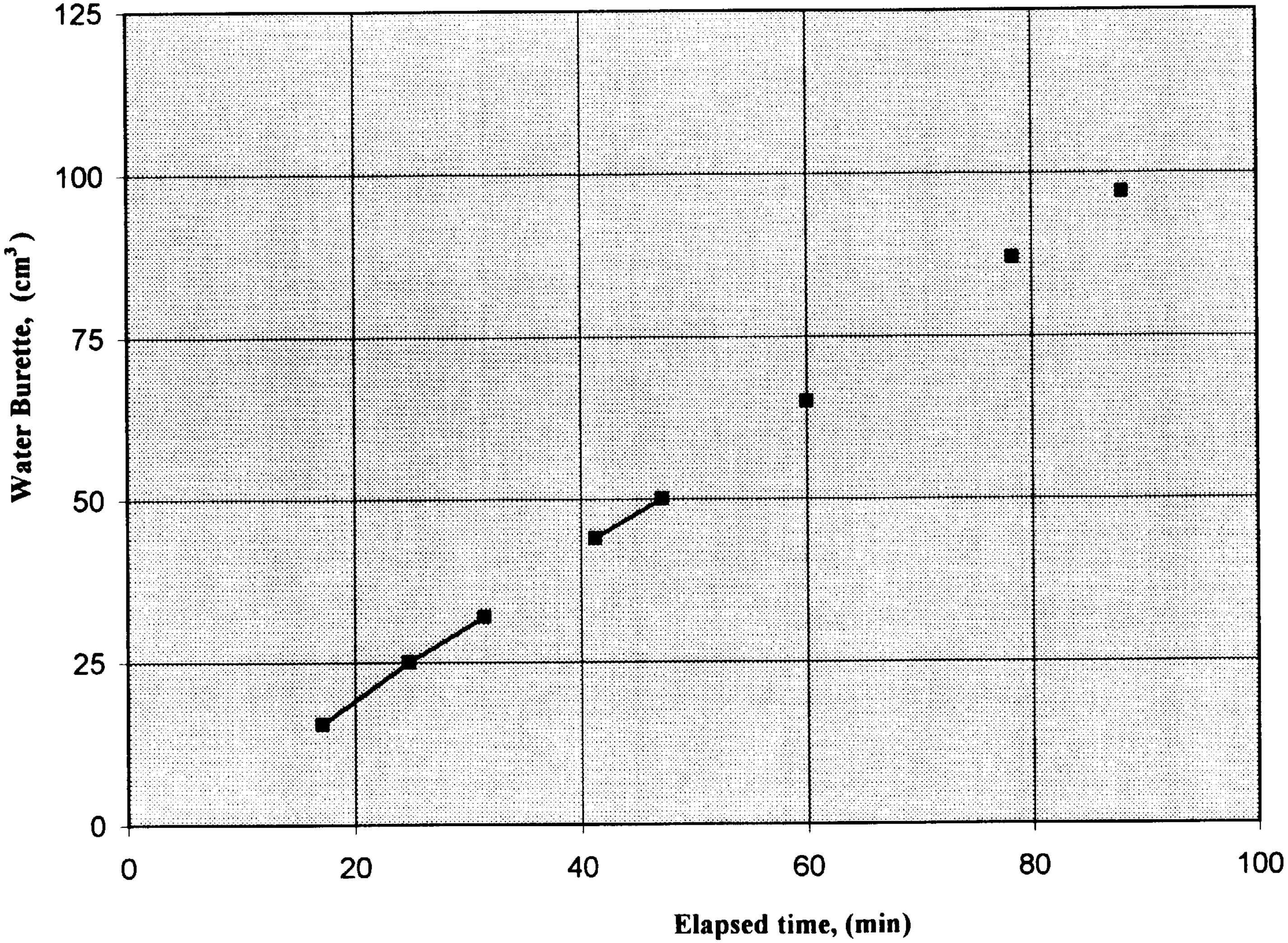
Run #14; Steam Reformation of Cellulose @ 1400°F - March 26, 1996

Gasified Polyethylene mass: 6.56 grams 971.00 milliequivs)

Time	Elapsed Time of Test	Water Flow In		Flow	Pressure	Helium Flow		<------ Oxygen Flow ------>			Gaseous Effluents Recovered						
		Burrette Reading		Circuit	P_3/P_5	Rotameter	flow	Rotameter	flow	mequiv/	<-------------- (millimoles / min) -------------->						
	(minutes)	(cm³)	(cc/min)	Sampled	(psig)	Reading	(scc/min)	Reading	(scc/min)	min	H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
			center heater still out - set bottom heater to 1600°F														
3:15	0.00		bottom heaters on														
3:22:20	7.33	5.0	1.12		110/98	40	145.22	-	-	-							
3:32:10	17.17	15.5	1.12		110/95	41.5	152.06	-	-	-							
3:39:45	24.75	25.0	1.12		97/90	45	170.72	-	-	-							
3:46:25	31.42	32.0	1.12		97/92	45	173.98	-	-	-							
3:54	39.00		water admitted to test rig; No. 1 furnace on.														
3:56:15	41.25	44.0	1.15		98/92	45	173.98	-	-	-							
4:02:05	47.08	50.0	1.16		108/85	35.5	101.85										
4:05:30	50.50		2nd furnace on - appears to be working														
4:09:45	54.75		**Bag (T2 = 160-176°C)**				67.59					1.8812	7.0546	-	-	0.0588	Gasifier
4:15	60.00	65.0	1.20		115/85	22	44.13	-	-	-							
4:23:30	68.50		**Bag**				46.05					0.0016	0.0449	0.0137	0.0016	0.0098	Gasifier
4:32	77.00		T2 = 176°C														
4:33:20	78.33	87.0	1.03		114/87	23	48.26	-	-	-							
4:36	81.00		**Bag**				48.65					0.0014	0.0389	0.0082	-	0.0123	Gasifier
4:41	86.00		T2 = 221°C														
4:43	88.00		1.03		114/90	23	49.69	-	-	-							
4:43	88.00	97.0	water flow shut off														
4:44	89.00		all furnaces off														
4:44:15	89.25		T2 = 279°C														
5:00	105.00		end run - system shut down														

Run #14: Steam Reformation of Cellulose @ 1400°F

Note: carrier gas (helium) flow @ 132 scc/min



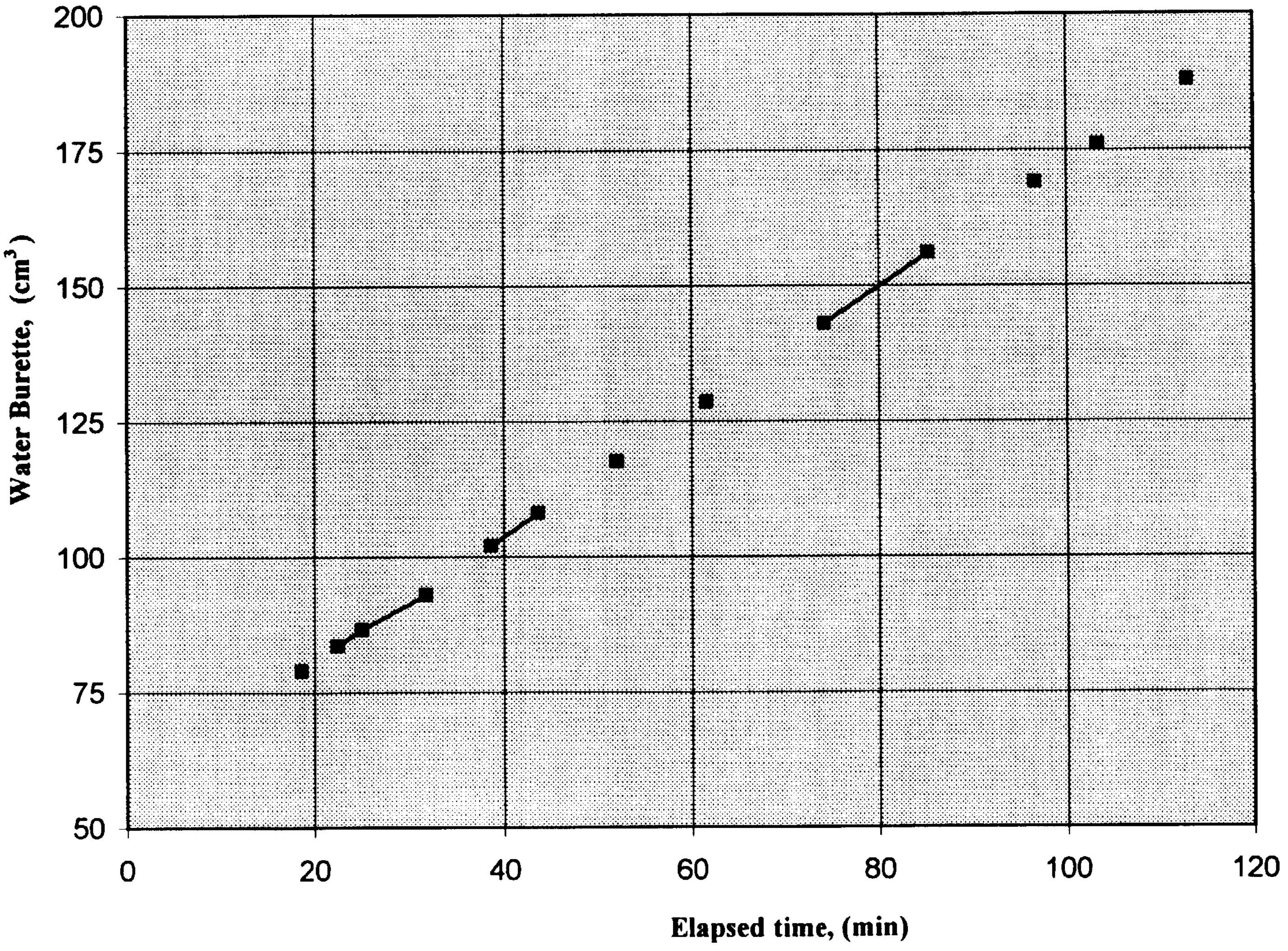
Run #15; Steam Reformation of Cellulose Char @ 1400°F - March 28, 1996

Gasified Cellulose Char: 3.03 grams (1009.08 milliequivs)

Time	Elapsed Time	Water Flow In		Flow	Pressure	Helium Flow		<------ Oxygen Flow ------>			Gaseous Effluents Recovered						
	of Test	Burrette Reading		Circuit	P_3/P_5	Rotameter	flow	Rotameter	flow	mequiv/	<--------------- (millimoles / min) --------------->						
	(minutes)	(cm³)	(cc/min)	Sampled	(psig)	Reading	(scc/min)	Reading	(scc/min)	min	H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
9:38	0.00		bottom heaters on (1st run with strip chart recorder)														
9:41:40	3.67	62.0	1.14		99/95	39	134.49	-	-	-							
9:56:35	18.58	79.0	1.14		99/90.5	39	128.97	-	-	-							
10:00	22.00		top (gasifier) furnace on														
10:00:25	22.42	83.5	water admitted to test rig														
10:03	25.00	86.5	1.15		104/94	40	140.07	-	-	-							
10:09:45	31.75	93.0	1.15		107/86.5	32	85.01	-	-	-							
10:14	36.00		**Bag**				54.78					0.0322	0.1032	-	-	0.0264	Gasifier
10:16:40	38.67	102.0	1.16		116/82	19.5	35.81	-	-	-							
10:21:40	43.67	108.0	1.16		121/89	15	27.58	-	-	-							
10:23:15	45.25		**Bag**				25.48					0.0069	0.0176	0.0865	0.0151	0.0865	Gasifier
10:30	52.00	117.5	1.16		123/85	8	16.53	-	-	-							
10:35	57.00		problems wi plugging - back pressure dropped to 70 psig														
10:39:40	61.67	128.5	1.16		120/65	0	10.55	-	-	-	<< Air contamination of bag sample @ 10:48 >>						
10:48:15	70.25		**Bag**				10.45					0.2735	0.8548	0.3077	0.0598	0.2137	Gasifier
10:52:10	74.17	143.0	1.16		136/64	0	10.41	-	-	-							
11:03:15	85.25	156.0	1.15		130/58.5	0	9.69	-	-	-							
11:11:55	93.92		**Bag**				106.09				0.7808	0.0501	0.2017	0.4230	0.0052	0.7093	Reformer
11:14:45	96.75	169.0	1.15		92/87	41	137.61	-	-	-							
11:20	102.00		**Bag**				136.85				0.0052	0.1031	0.3350	0.0644	0.0052	0.3350	Reformer
11:21:25	103.42	176.0	1.15		98/94	39.5	136.64	-	-	-							
11:27:30	109.50		**Bag**				138.82					0.1030	0.3606	-	0.0052	0.2962	Reformer
11:31	113.00	187.8	water flow off		99/94	40	140.07	-	-	-							
11:33	115.00		end run - system shut down														

Run #15: Steam Reformation of Cellulose Char @ 1400°F

Note: carrier gas (helium) flow @ 132 scc/min



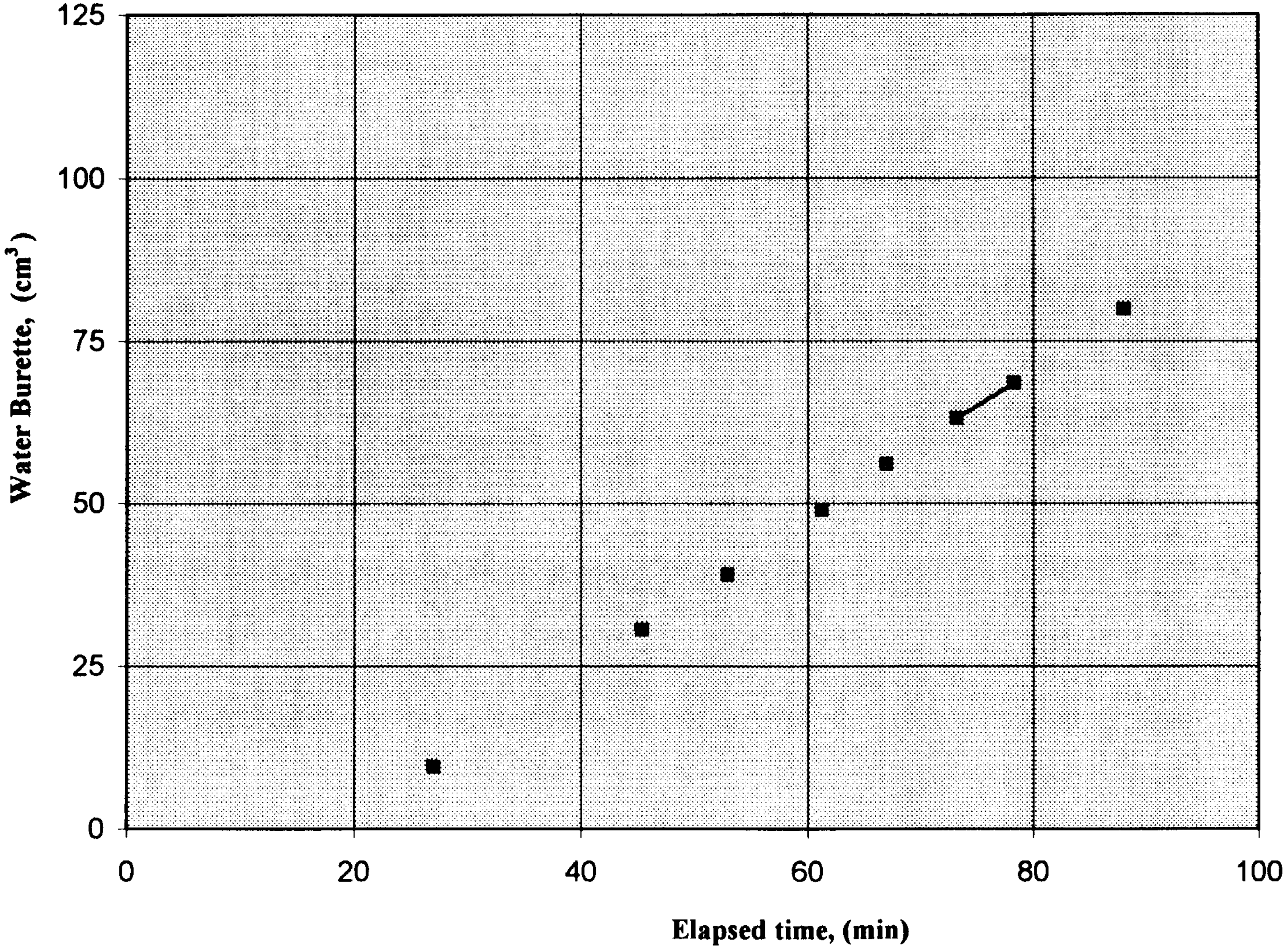
Run #16; O2 Enriched Steam Reformation of Butyric Acid @ 1600°F - March 31, 1996

Gasified Mass Butyric Acid: 5.37 grams (1219.0 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In		Flow Circuit Sampled	Pressure	Helium Flow		<—— Oxygen Flow ——>			Gaseous Effluents Recovered						
		Burrette Reading (cm³)	(cc/min)		P_3/P_5 (psig)	Rotameter Reading	flow (scc/min)	Rotameter Reading	flow (scc/min)	mequiv/ min	<———— (millimoles / min) ————>						
											H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
12:50	0.00		bottom heaters on														
12:55	5.00				103/97	40.5	147.51	-	-	-							
1:02	12.00				98/92	42.5	155.09	-	-	-							
1:17	27.00	9.5	1.15		99/94	41	147.09										
1:19:30	29.50		**Bag (T2 = 142°C)**				147.09					3.0498	4.7926	-	0.3921	0.2759	Reformer
1:23:45	33.75	[17.2]	water flow to gasifier started														
1:29:15	39.25		**Bag (T2 = 164°C)**									0.0466	0.0519	0.2978	0.1833	0.9544	Reformer
1:32	42.00		oxygen flow started														
1:35:20	45.33	30.5	1.12		101/94	41	147.09	3.5	38.30	6.263							
1:38:23	48.38		**Bag (T2 = 190-196°C)**				149.26				3.3234	0.0208	0.1090	2.0598	1.1943	4.5004	Reformer
1:42:55	52.92	39.0	1.20		102/98	41	152.50	2.0	37.98	6.210							
1:45:50	55.83		turn on top furnace (No. 1)														
1:46:20	56.33		**Bag (T2 = 220-250°C)**														
1:51:15	61.25	49.0	1.22		103/96	40	142.65	1.0	36.37	5.946							
1:55:30	65.50		**Bag (T2 = apprx 320°C)**				140.74					10.153	33.165	5.9562	1.1506	11.506	Reformer
1:57	67.00	56.0	1.10		98/94	40	140.07	0.5	35.30	5.772							
2:01:30	71.50		**Bag (T2 = apprx 320°C)**				140.07				0.7932	0.0168	0.0802	0.2240	0.3919	2.0995	Reformer
2:03:15	73.25	63.0	1.10		103/94	40	140.07	1.5	36.15	5.911							
2:08:20	78.33	68.5	**Bag (T2 = 560-600°C)**				144.98				0.3442	0.0128	0.0568	0.0801	0.1121	1.4730	Reformer
2:10	80.00		**Bag (T2 => 650°C)**				146.59										
2:18	88.00	79.8	1.17		99/94	42	154.31	2.0	36.63	5.990							
2:18	88.00		water flow, furnaces shut off														
2:18	88.00		end run - system shut down														

Run #16: Steam Reformation of Butyric Acid @ 1600^{o}F

Note: carrier gas (helium) flow @ 132 scc/min



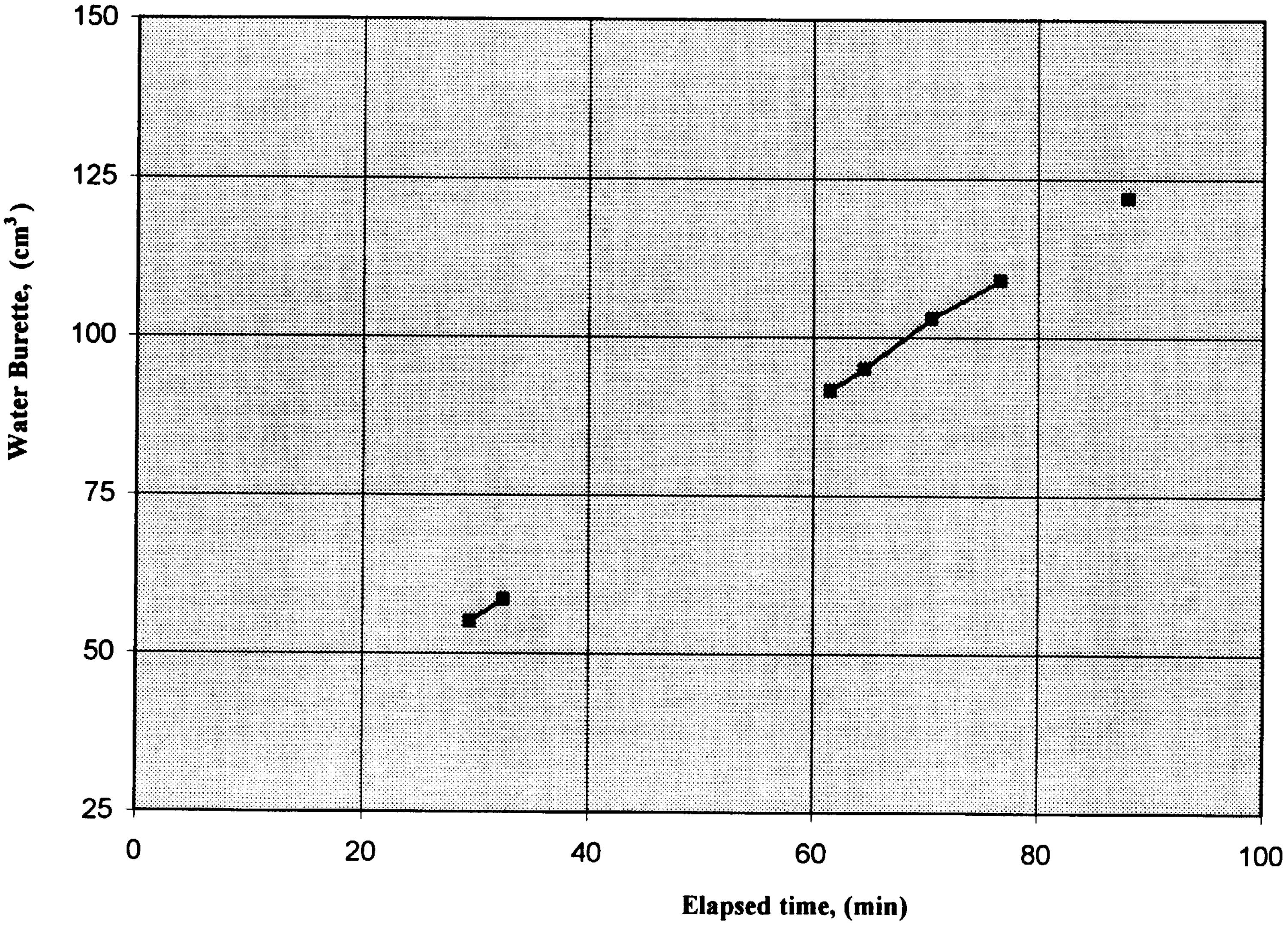
Run #17; Steam Reformation of Methionine @ 1600°F (with & w/o O2) - April 1, 1996

Gasified Mass Methionine: 4.76 grams (989.0 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	Water Flow In (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<------ Oxygen Flow ------> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/min	Gaseous Effluents Recovered <-------------- (millimoles / min) --------------> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols/min	mmols/min	mmols/min	mmols/min	mmols/min	mmols/min	
1:40	0.00		bottom heaters on														
1:57:25	17.42	41.0	1.16		98/93.5	43	161.00	-	-	-							
2:02	22.00		1.16		97/93	43	160.26	-	-	-							w/o O_2
2:06	26.00		1.16		97/92	43	158.77	-	-	-							
2:06:30	26.50		**Bag (T2 = 84-100°C)**				156.98					0.0033	0.0664	-	-	0.0189	Reformer
2:09	29.00		start water flow to gasifier														↑
2:09:30	29.50	55.0	1.17														w/o O_2
2:12:30	32.50	58.5	1.14		97/90.5	40	135.56	-	-	-							↓
2:16:30	36.50		**Bag (T2 = 125-185°C)**				135.56					0.0072	0.0022	-	-	0.0184	Reformer
2:21:30	41.50		1.14		97/90.5	40	135.56	-	-	-							
2:22:40	42.67		**GC w/o O2 (T2 = 190-200°C)**				139.95					-	-	-	0.0090	0.2763	Reformer
2:25	45.00		oxygen flow started; Turn on furnace No. 1:														
2:26:30	46.50		1.14		99/91.5	42.5	154.37	-	34.61	5.66							
2:31:30	51.50		**Bag (T2 = approx 210°C)**				150.54		↑			0.2665	1.0033	-	0.0462	0.3684	Reformer
2:34:15	54.25		1.14		103/95	41	148.44	-									
2:37:45	57.75		**Bag (T2 = approx 255°C)**				145.58							0.0113	0.4055	1.1414	Reformer
2:41:30	61.50	91.5	1.15		100/92												
2:44:30	64.50	95.0	1.15		101/94	40	140.07		↓								
2:50:30	70.50	103.0	1.15		101/93	40	138.78	0	34.61	5.659							
2:56:40	76.67	109.0	1.15		100/92	40	137.49	2.5	36.47	5.963							
2:58	78.00		**GC (T2 = approx 670°C)**				138.20								0.0071	0.2665	Reformer
3:01:30	81.50		1.15		102/94	40	140.07	2.0	36.63	5.990							
3:05	85.00		O2 & furnaces off														
3:08	88.00	122.0	water flow shut off														
			end run - system shut down														

Run #17: Steam Reformation of Methionine @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



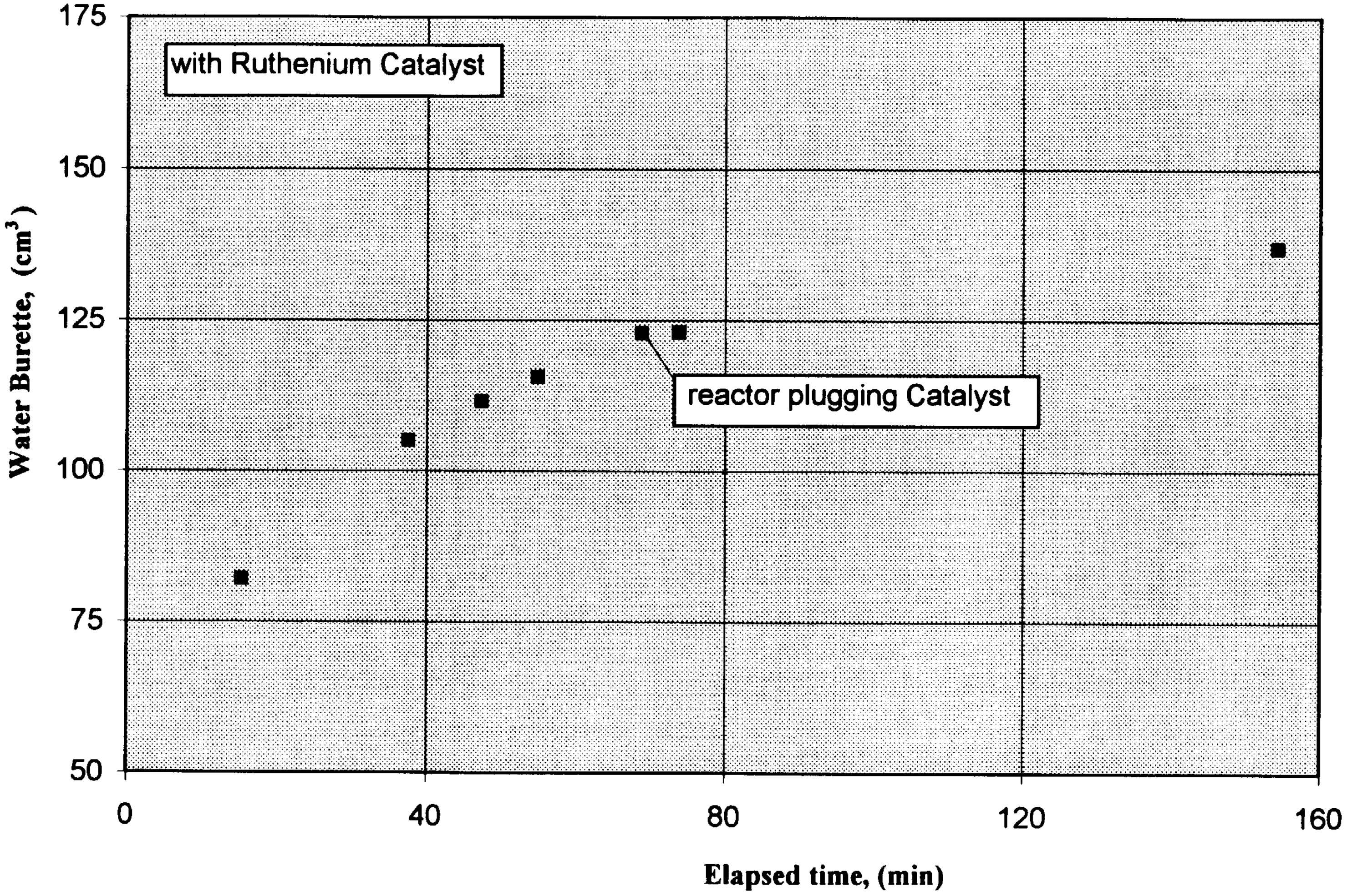
Run #18; Oxygen Enriched Reformation of Polyethylene @ 1600°F - April 4, 1996

Gasified Mass Polyethylene: 6.14 grams (2626.40 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm³)	Water Flow In Reading (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<—— Oxygen Flow ——> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/ min	Gaseous Effluents Recovered <———— (millimoles / min) ————> H_2 mmols/min	O_2 mmols/min	N_2 mmols/min	CO mmols/min	CH_4 mmols/min	CO_2 mmols/min	
11:08:25	0.00	63.0	bottom heaters on														
11:17:25	9.00	77.5	1.23		97/93	40	138.78	-	-	-							
11:23:50	15.42	82.0	1.23		98/92	40	137.49	-	-	-							
11:35	26.58		water flow started														
11:36	27.58		1.03		122/85	15	26.52	-	-	-							
11:45	36.58		oxygen flow started														
11:46:05	37.67	105.0	0.67		135/67	5	11.78	-	-	-							
11:50	41.58		water stroke reduced to 0.075"														
11:54	45.58		**GC (T2 = 180-190°C)**				11.53					-	-	-	-	-	Reformer
11:55:50	47.42	111.5	0.53		145/72	0	11.47	0	27.86	4.556							
11:59:30	51.08		**Bag (T2=190-680°C; til 12:42 to fill)**				11.47					-	-	-	-	-	Reformer
12:03:20	54.92	115.5	0.53		143/72	0	11.47	0	27.86	4.556							
12:11:30	63.08		turn on furnace No. 1														
12:17:15	68.83	122.9	complete plug: stop water flow														
12:17:15	68.83				150/68	0	10.94	0	26.58	4.346							
12:22:15	73.83	123.0															
12:32	83.58		green liquid (ruthenium) vented @ relief valve														
12:37	88.58				144/68	0	10.94	0	26.58	4.346							
1:00	111.58	1	**Bag (T2 = 740-760°C; Gasifier fill @ 1:05)**									0.0015	0.0013	0.0229	0.0552	0.1446	Ref/Gasifie
1:22	133.58				140/68	0	10.94	0	26.58	4.346							
1:22	133.58		net non-condensible flow thru gasifier 4.84 scc/min														
1:37	148.58				140/68	0	10.94	0	26.58	4.346							
1:42:45	154.33	137.0	water flow started again wi 0.050" stroke														
1:45	156.58		water flow stopped again														
2:15	186.58		end run - all systems shut down														

Run #18: O2 Enriched Reformation of Polyethylene @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



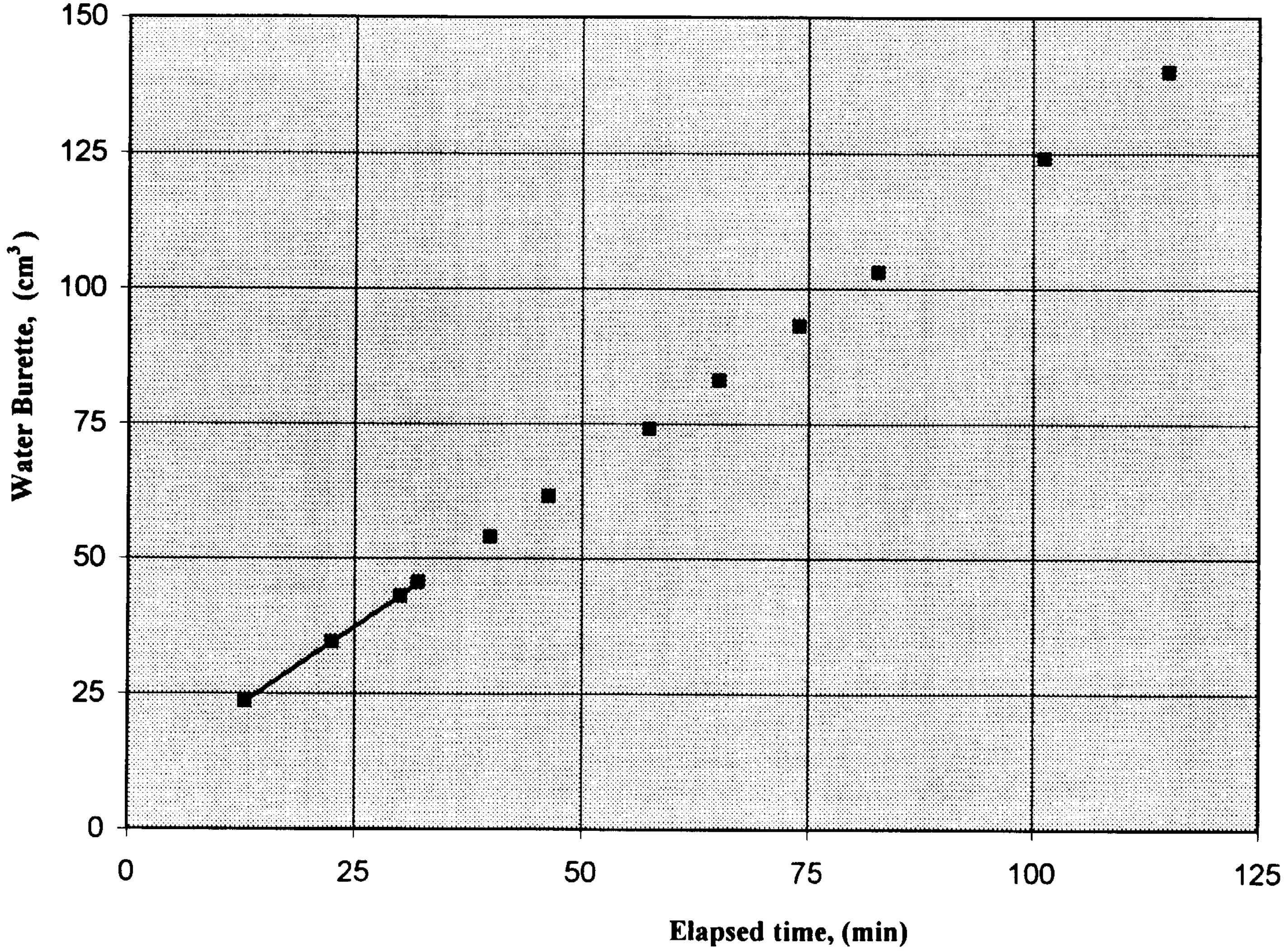
Run #19; O2 Enriched Reformation of Polyethylene @ 1600°F - April 15, 1996

Gasified Mass Polyethylene: 6.52 grams 2788.95 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	Water Flow In (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<------ Oxygen Flow ------> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/ min	Gaseous Effluents Recovered <-------------- (millimoles / min) --------------> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
							94.5										
1:30	0.00		bottom heaters on														
1:43	13.00	23.5	1.16		103/99	37	125.79	13	59.25	9.687							
1:52:30	22.50	34.5	1.16		100/94.5	40	140.71	13.5	58.24	9.524							
2:00	30.00	43	1.16		104/99	37	125.79	11.5	55.28	9.039							
2:02	32.00	45.5	start water flow to gasifier														
2:04	34.00		top furnace on (No. 1)														
2:07	37.00		**GC (T2 = approx 170°C)**				135.79					4.5204	0.0210	-	-	0.4205	Reformer
2:10	40.00	54	1.06		100/94	40	140.07	13.5	57.98	9.480							
2:15:45	45.75		**Bag (T2 = 180-250°C)**				126.10					1.9523	0.0263	-	-	0.3754	Reformer
2:16:20	46.33	61.5	1.18		103/98	37	124.68	12.0	56.07	9.168							
2:22:37	52.62		**Bag (T2 = 300-350°C)**			100	102.70					0.9334	1.7124	0.1249	0.0206	0.3601	Gasifier
2:25	55.00		switch flow back to reformer side														
2:27:30	57.50	74	1.12		109/100	30	85.61	7.0	45.89	7.504							
2:31:45	61.75		**Bag (T2 = 550-600°C)**				84.38				1.5005	0.0239	0.0327	0.2660	0.5320	1.0163	Reformer
2:35:15	65.25	83	1.16		108/97	30	83.37	6.0	42.98	7.027							
2:43	73.00		**GC (T2 = 680-700°C)**				99.12				1.6451	-	0.0141	0.1802	0.1567	1.7861	Reformer
2:44	74.00	93.0	1.14		107/99	33	101.15	5.0	42.16	6.893							
2:50	80.00		**Bag (T2 = approx 725°C)**				116.38				0.117	0.638	0.025	0.103	0.302	0.920	Gasifier
2:52:50	82.83	103	1.13		101/97	37	123.58	12.0	55.57	9.086							
2:54	84.00		switch flow back to reformer side														
3:00	90.00		switch flow back to gasifier														
3:11:15	101.25	124	1.15		99/104	38	138.31	12.0	59.05	9.656							
3:22	112.00		**GC (T2 = approx 750°C)**				138.31					1.729	-	-	-	0.135	Gasifier
3:23	113.00		oxygen flow shut off														
3:25	115.00	140	water flow shut off														
3:31:30	121.50		furnaces shut down														
			end run - system shut down														

Run #19: O2 Enriched Reformation of Polyethylene @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



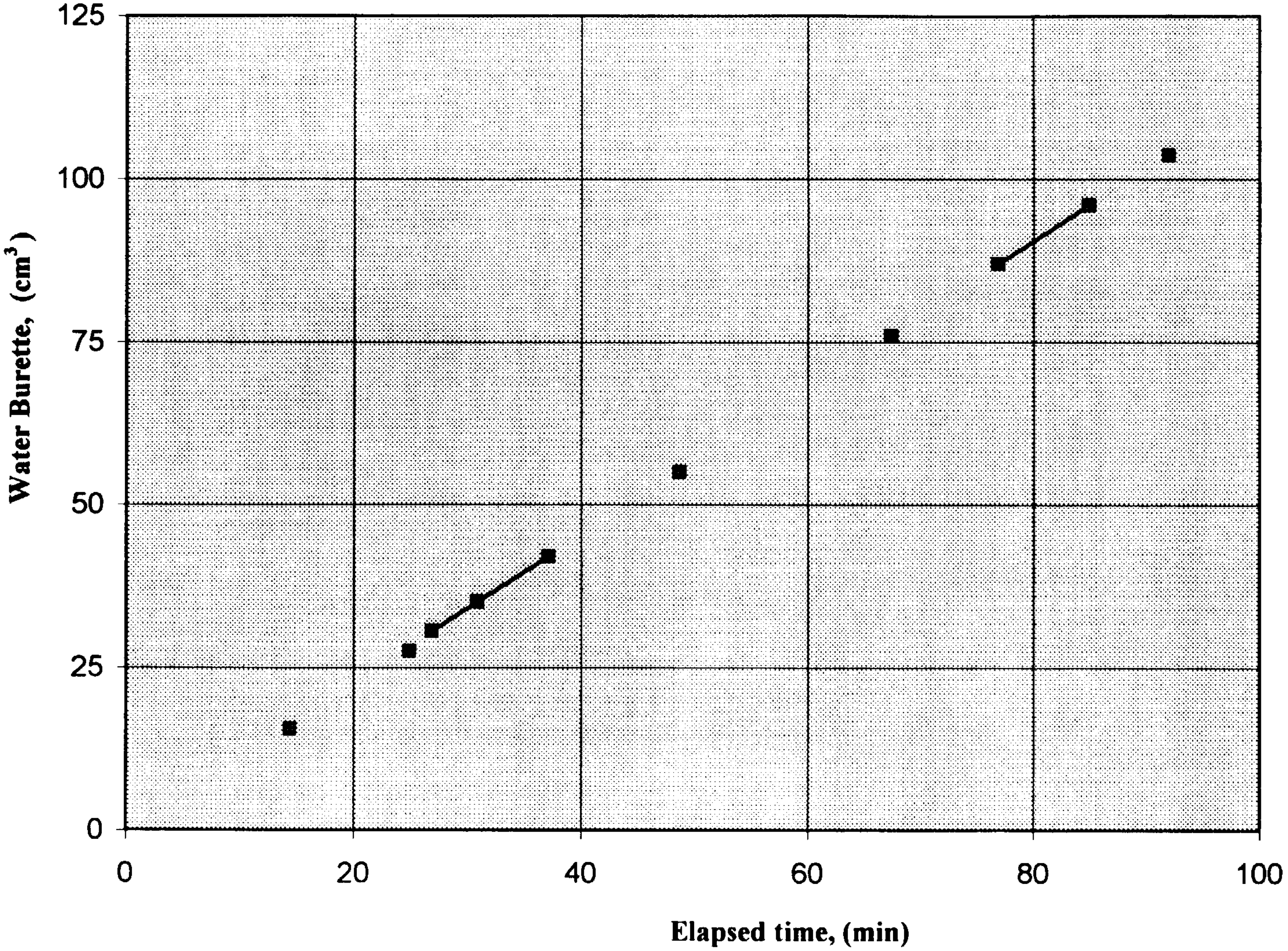
Run #20; O2 Enriched Reformation of Methionine @ 1600°F - April 17, 1996

Gasified Mass of Methionine: 6.10 grams (1267.4 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	Water Flow In Burrette Reading (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<------ Oxygen Flow ------> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/min	Gaseous Effluents Recovered <------------- (millimoles / min) -------------> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
2:30:05	0.00		bottom heaters on														
2:44:30	14.42	15.5	1.16		103/99	40	146.51	0	36.54	5.975							
2:51	20.92		O2 flow to gasifier on														
2:55	24.92	27.5	1.16		103/98.5	40	145.87	15.0	64.79	10.594							
2:57	26.92		switch top furnace (No. 1) on														
2:57	26.92	30.5	water flow on														
3:01	30.92	35	1.16		102/99	40	146.51	14.5	63.56	10.393							
3:07:15	37.17	42	1.13		102/97	40	143.93	15	63.93	10.454							
3:10	39.92		**GC (T2 = approx 200°C)**				144.24					2.5377	0.0088	0.0488	-	1.2689	Gasifier
3:15:22	45.28		**Bag (T2 = 280-300°C)**				144.84				0.8289	2.6348	5.8617	0.3256	0.7697	13.263	Reformer
3:18:45	48.67	55	1.12		104/98	40	145.22	15	64.50	10.547							
3:18:50	48.75		**Bag (T2 = approx 300°C)**				145.24				0.7772	0.3000	0.0491	0.7500	2.1408	3.6817	Gasifier
3:27	56.92		**Bag (T2 = approx 650°C)**				146.92				4.5040	0.0932	0.2578	0.3262	0.0264	4.3177	Reformer
3:37	66.92		**Bag (T2 = approx 700°C)**				148.99				0.7667	0.6637	0.0549	0.5722	1.1215	2.1743	Gasifier
3:37:30	67.42	76	1.13		104/101	40	149.09	15	66.22	10.828							
3:46	75.92		**GC (T2 = approx 720°C)**				135.27				1.9654	0.0080	0.0782	0.0759	0.0092	3.8274	Reformer
3:47	76.92	87	1.13		105/100	38	133.65	14	62.63	10.241							
3:55	84.92	96	1.13		106/101	37	128.00	14.5	64.68	10.576							
4:00	89.92		O2 bottle shut off														
4:02	91.92	103.7	water flow shut off														
4:05	94.92				102/98	38	131.32	-	-	-							
4:10	99.92		end run - system shut down														

Run #20: O2 Enriched Reformation of Methionine @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



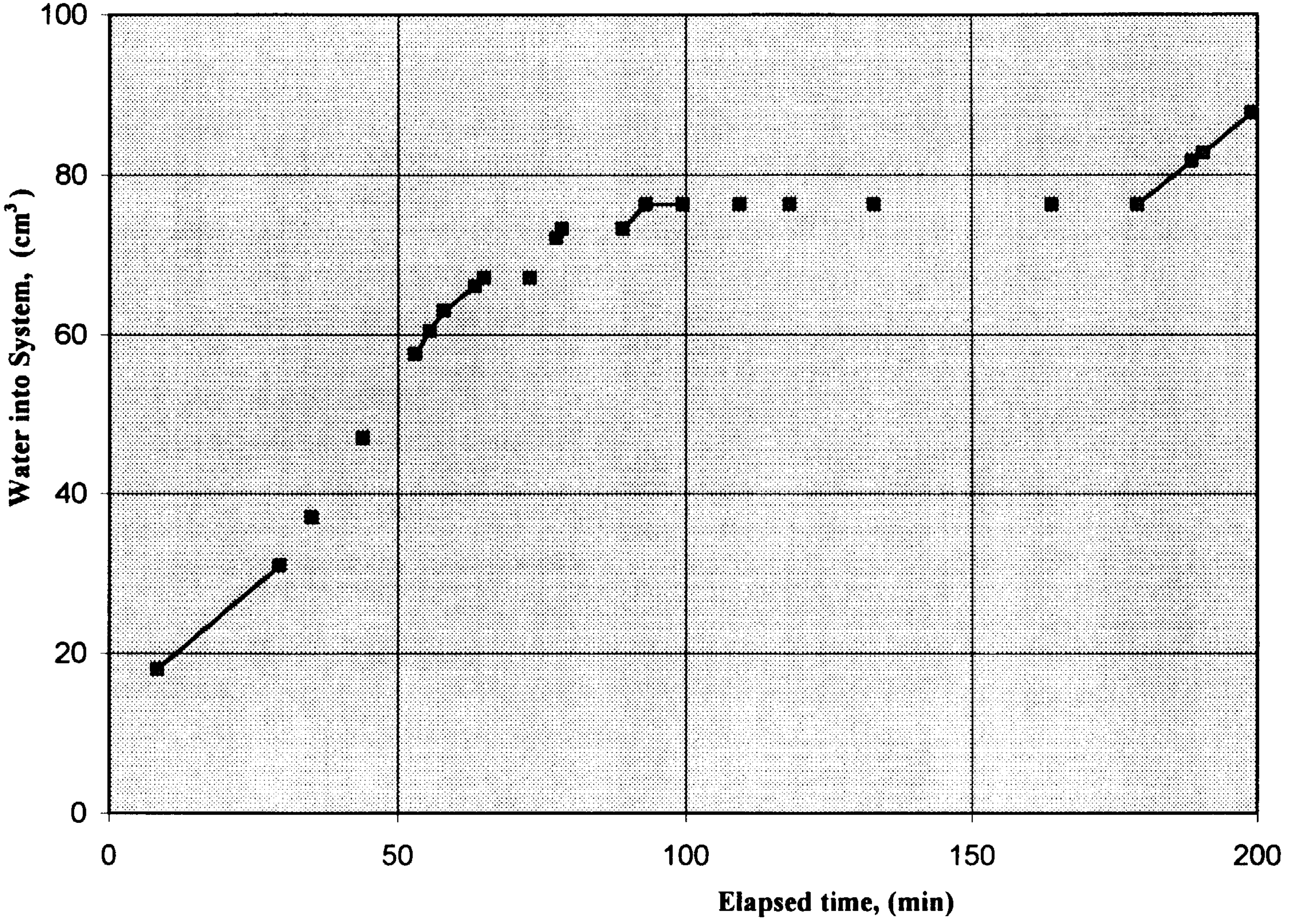
Run #21; O2 Enriched Steam Reformation of Urea @ 1600°F - April 19, 1996

Gasified Mass of Urea: 6.92 grams (691.4 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)	HIDE	(cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<------ Oxygen Flow ------> Rotameter Reading	flow (scc/min)	mequiv/ min	Gaseous Effluents Recovered <--------------- (millimoles / min) ---------------> H_2	O_2	N_2	CO	CH_4	CO_2	
												mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
1:29	0.00			bottom heaters on: helium & O2 on														
1:37:20	8.33	18.0	18.0	0.61		105/100	37	126.90	15	65.65	10.734							
1:58:30	29.50	31	31.0	1.09		104/99	37	125.79	15	65.08	10.641							
2:00	31.00			water flow into rig; switch No. 1 furnace on														
2:03	34.00			**GC (T2 = 100°C)**				126.70					4.3159	-	-	-	0.0959	Reformer
2:04	35.00	37	37.0	1.11		107/100	37	126.90	15	65.65	10.734							
2:07	38.00			**Bag (T2 = approx 145°C)**				130.65					2.5432	-	-	-	0.5934	Reformer
2:12	43.00			**Bag (T2 = 150-160°C)**				136.91				0.2030	1.6767	0.6883	0.0071	-	0.6530	Gasifier
2:13	44.00	47	47.0	1.17		103/98	39	138.16	18	74.33	12.154							
2:14	45.00			swith flow back thru reformer														
2:17	48.00			**Bag (til 3:10 PM to fill; T2 = 300-740°C)**								1.277	4.034	9.637	-	-	1.815	Reformer
2:22	53.00	57.5	57.5	1.04		127/92	12	22.85	0	34.29	5.607							
2:24:30	55.50		60.42	cut water flow in half (micrometer @ 0.050")														
2:27	58.00	63	63.0	1.04		131/88	10	19.21	0	33.00	5.397							
2:32:30	63.50	66	66.0			129/87	10	19.03	0	32.68	5.344							
2:34	65.00		67.05	bypass water (but restore 0.100" stroke)														
2:35:45	66.75	68.5																
2:42	73.00	76	67.0	feed water back into system														
2:42	73.00					107/88	33	91.36	14	56.08	9.169							
2:46:30	77.50	81	72.0			122/91	18	35.08	2	35.62	5.825							
2:47:30	78.50		73.18	bypass water (0.100" stroke restored)														
2:57:30	88.50	93.5				105/89	34	97.58	15	59.35	9.705							
2:58	89.00		73.2	feed water back into system														
3:02	93.00		76.27	bypass water again														
3:08:30	99.50	102	76.27			125/100	12	24.56	0	36.86	6.027							
3:11	102.00			**GC (T2 = approx 740°C)**				36.85					0.1648	0.1010	-	-	0.2885	Reformer
3:18:30	109.50	118	76.3	1.04		112/97	28	73.71	14	60.99	9.973							
3:25:30	116.50			**Bag (T2 = 740-750°C)**				55.36					0.8308	0.0698	-	-	0.1595	Reformer
3:27:15	118.25	128	76.3			117/100	22	50.77	4	41.08	6.717							
3:35:15	126.25	137.5				115/101	22	51.22	5	42.90	7.014							
3:42	133.00	145	76.3			114/101	23	54.91	7	46.29	7.570							
3:53	144.00			**GC (w/o water flow; T2 = 760°C)**									2.9115	0.0104	-	-	0.0328	Reformer
3:57	148.00	163				113/101	23	54.91	8	48.23	7.886							
4:13	164.00	181.5	76.3			113/101	25	62.88	13.5	61.71	10.091							
4:27:30	178.50	198				113/101	25	62.88	13.5	61.71	10.091							
4:28	179.00		76.3	start water again wi 0.050" stroke														
4:37:30	188.50	204	81.7004			126/101	15	30.77	0	37.18	6.080							
4:38	189.00			**GC (w 1/2 water flow; T2 = 760°C)**									1.9725	-	-	-	0.0032	Reformer
4:39:30	190.50	205	82.7004			118/101	25	62.88	8	48.23	7.886							
4:48	199.00	210	87.7004	water flow shut off														
4:56	207.00					122/75	54	212.58	21	68.09	11.133							
5:09	220.00					121/74	62	280.71	23	73.82	12.071							
5:22	233.00			**GC (w/o water flow; T2 = 760°C)**									6.6121	-	-	-	0.0094	Reformer
5:23	234.00					119/74	64	300.17	25	80.80	13.212							
5:34	245.00			end run - system shut down														

Run #21: O2 Enriched Steam Reformation of Urea @ 1600°F

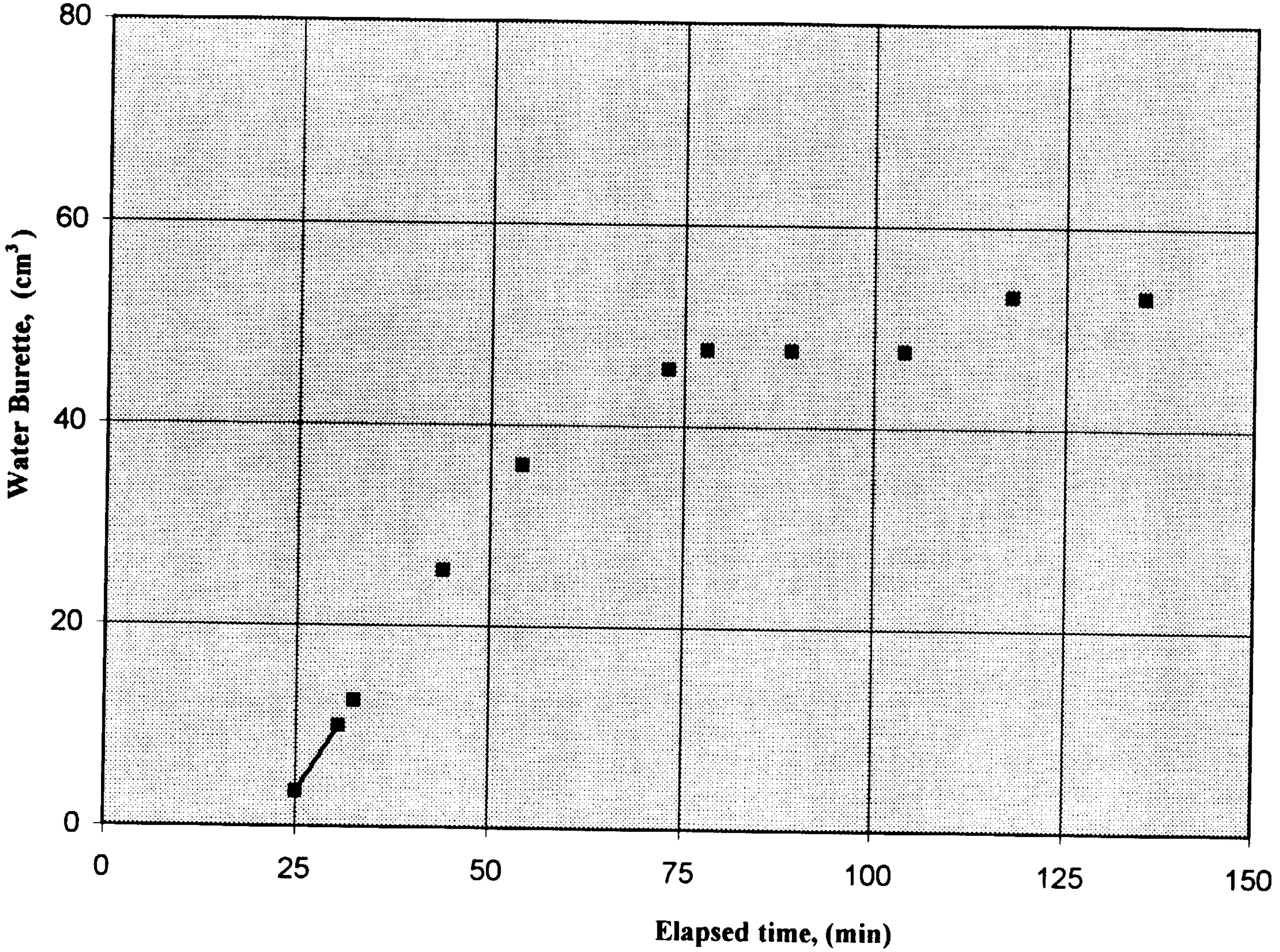
Note: carrier gas (helium) flow @ 132 scc/min



Run #22; O_2 Enriched Reformation of IGEPON TC-42 @ 1600°F - April 23, 1996

Gasified Igepon TC-42 mass: 7.04 grams (516.32 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm^3)		(cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<—— Oxygen Flow ——> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/min	Gaseous Effluents Recovered <———— (millimoles / min) ————> H_2	O_2	N_2	CO	CH_4	CO_2	
												mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
2:50	0.00			bottom furnaces on; flow thru reformer														
3:06	16.00			oxygen flow started														
3:15	25.00	3.5	3.5	1.20		102/98	37	124.68	14.5	63.00	10.301							
3:20:30	30.50	10	10	1.20		103/98	37	124.68	14.5	63.00	10.301							
3:21	31.00			top furnace (No. 1) on														
3:22:30	32.50	12.5	12.5	water flow started														
3:25:30	35.50			1.13		103/98	36	118.26	14	61.54	10.062							
3:28	38.00			**Bag (150-160°C)**				120.73					-	-	-	-	-	Reformer
3:34	44.00	25.5	25.5	1.13		98/94	38	126.66	16.5	66.79	10.920							
3:34:15	44.25			**Bag (160-200° - leaky bag!)**				123.41					-	-	-	-	-	Gasifier
3:37	47.00			switch flow to reformer														
3:42	52.00			1.05		129/91	12	22.63	0	33.97	5.554							
3:42:30	52.50			**Bag (300-400° - til 3:55 to fill)**				22.13					1.0493	0.1329	-	-	0.2448	Reformer
3:44	54.00	36	36	cut water stroke to 0.050" - O2 & helium not registering														
3:50	60.00	39				140/96	0	14.65	0	35.58	5.817							
3:54	64.00					137/96	0	14.65	0	35.58	5.817							
3:56	66.00			**Bag (600-750° - til 4:46 PM to fill)**				14.48					-	-	-	-	-	Reformer
4:03	73.00		45.65	cut water stroke to 0.040"														
4:06:30	76.50	47		-1.03		135/88	0	13.59	0	33.00	5.397							
4:08	78.00		47.58	water flow shut off														
4:17:30	87.50	48				134/85	0	13.19	0	32.04	5.239							
4:19	89.00		47.58	vent overpressure condition thru gasifier **(1/3 fill of 3:56 PM bag)**														
4:26	96.00	48				111/85	14	24.64	28	103.62	16.943							
4:34	104.00	48	47.58	turn water back on (0.040" stroke)														
4:44	114.00	52.0		0.09		132/96	0	14.65	0.0	35.58	5.817							
4:46	116.00			blowdown to 60 psi to **fill 3:56 PM Bag**														
4:48	118.00	53.5	53.1	water flow shut off														
4:48	118.00			**Bag (750°C)**				25.28					0.0263	0.0204	-	-	0.3794	Reformer
4:50	120.00			blowdown to 36 psi to **fill 4:48 PM Bag**														
5:05:30	135.50	54.0	53.1	0.09		98/41	40	71.77	22.0	44.28	7.240							
5:06	136.00			end run - system shut down														



Run #22: Steam + O_2 Reformation of IGEPON TC-42 @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min

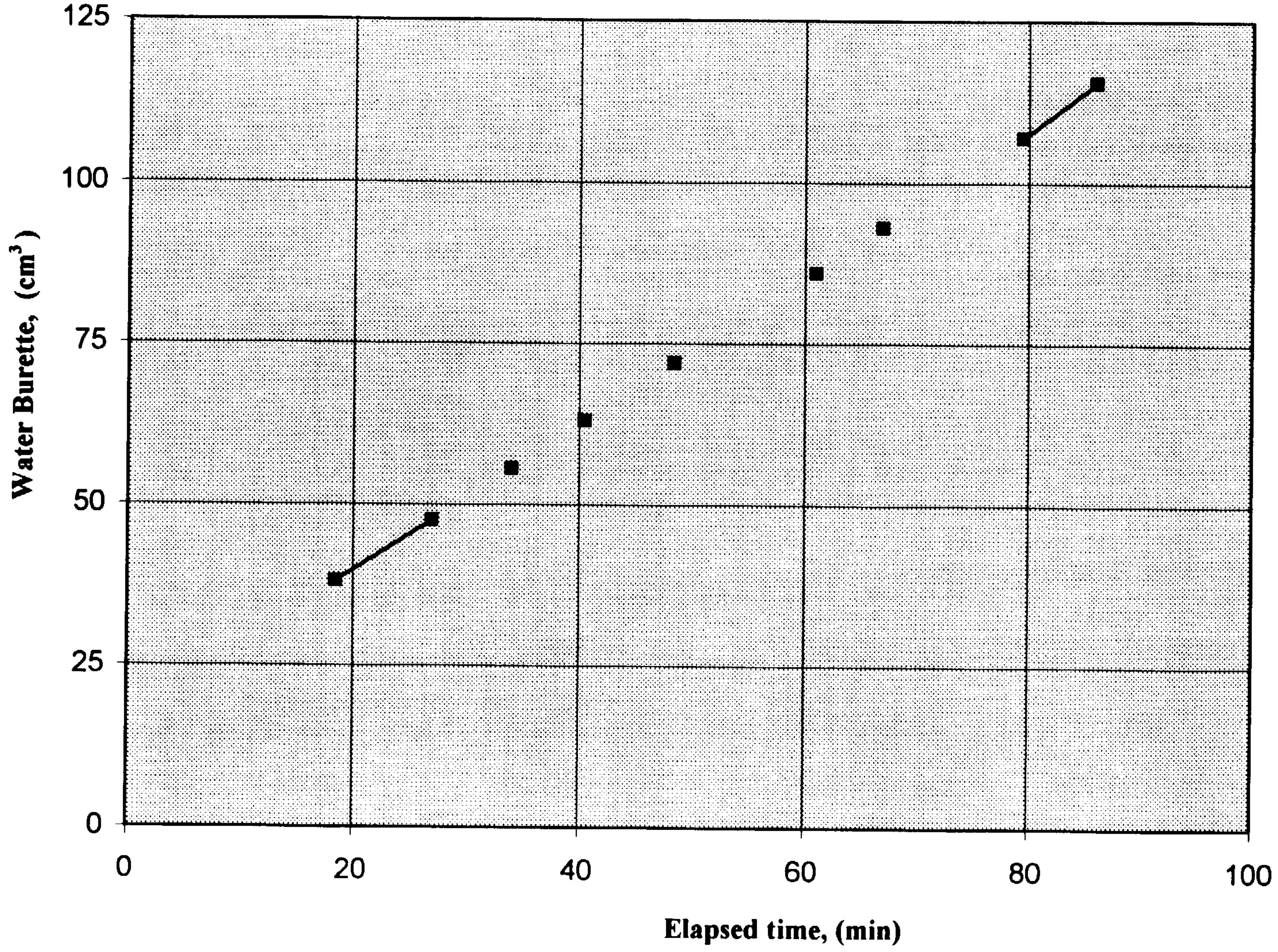
Run #23; O2 Enriched Steam Reformation of Referee Mix @ 1600°F - April 30, 1996

Gasified Mass Referee Mix: 6.18 grams (947.7 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In		Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow		<—— Oxygen Flow ——>			Gaseous Effluents Recovered <———— (millimoles / min) ————>						
		Burrette Reading (cm^3)	(cc/min)			Rotameter Reading	flow (scc/min)	Rotameter Reading	flow (scc/min)	mequiv/ min	H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
2:00	0.00		bottom heaters & helium flow on														
2:16	16.00		start O2 flow into rig														
2:18:30	18.50	38	1.12		100/96	36	116.16	14	60.44	9.883							
2:27	27.00	47.5	1.14		102/98	36	118.26	14	61.54	10.062							
2:30	30.00		start water flow (stroke 0.100")														
2:34	34.00	55.5	1.15		102/96	36	116.16	14	60.44	9.883							
2:37	37.00		top furnace (No. 1) on														
2:40:30	40.50	63	1.13		102/96	37	122.47	14.5	61.88	10.119							
2:41	41.00		**GC (T2 = 160°C)**				122.27					11.386	0.7912	-	-	2.1228	Reformer
2:42	42.00		switch flow to gasifier														
2:48	48.00		**Bag (T2 = 160-180°C)**				119.49					0.2827	0.0288	0.0277	0.0043	0.1067	Gasifier
2:48:30	48.50	72	1.12		101/96	36.5	119.29	14.5	61.88	10.119							
2:52	52.00		switch flow to reformer														
2:56	56.00		**Bag (T2 = 350-550°C)**				117.42					0.308	0.281	-	-	33.101	Reformer
3:01	61.00	86.0	1.17		101/96	36	116.16	14.0	60.44	9.883							
3:01:30	61.50		**Bag (T2 = 600-630°C)**				115.82					0.0644	0.0147	2.0515	2.5074	4.0359	Gasifier
3:07	67.00	93.0	1.12		103/98	35	112.05	14.0	61.54	10.062							
3:09:37	69.62		**Bag (T2 = approx 700°C)**				114.37					0.0080	0.0159	0.1767	0.0725	3.8880	Reformer
3:14	74.00		1.12			36	118.26	14.5	63.00	10.301							
3:15	75.00		**GC (T2 = approx 730°C)**				119.23					0.0109	0.0153	3.0625	1.8375	12.075	Gasifier
3:19:30	79.50	107.0	1.31		102/97	37	123.58	14.0	60.99	9.973							
3:26	86.00	115.5	water flow, furnaces shut off														
3:30	90.00		end run - system shut down														

Run #23: Steam Reformation of Referee Mix @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



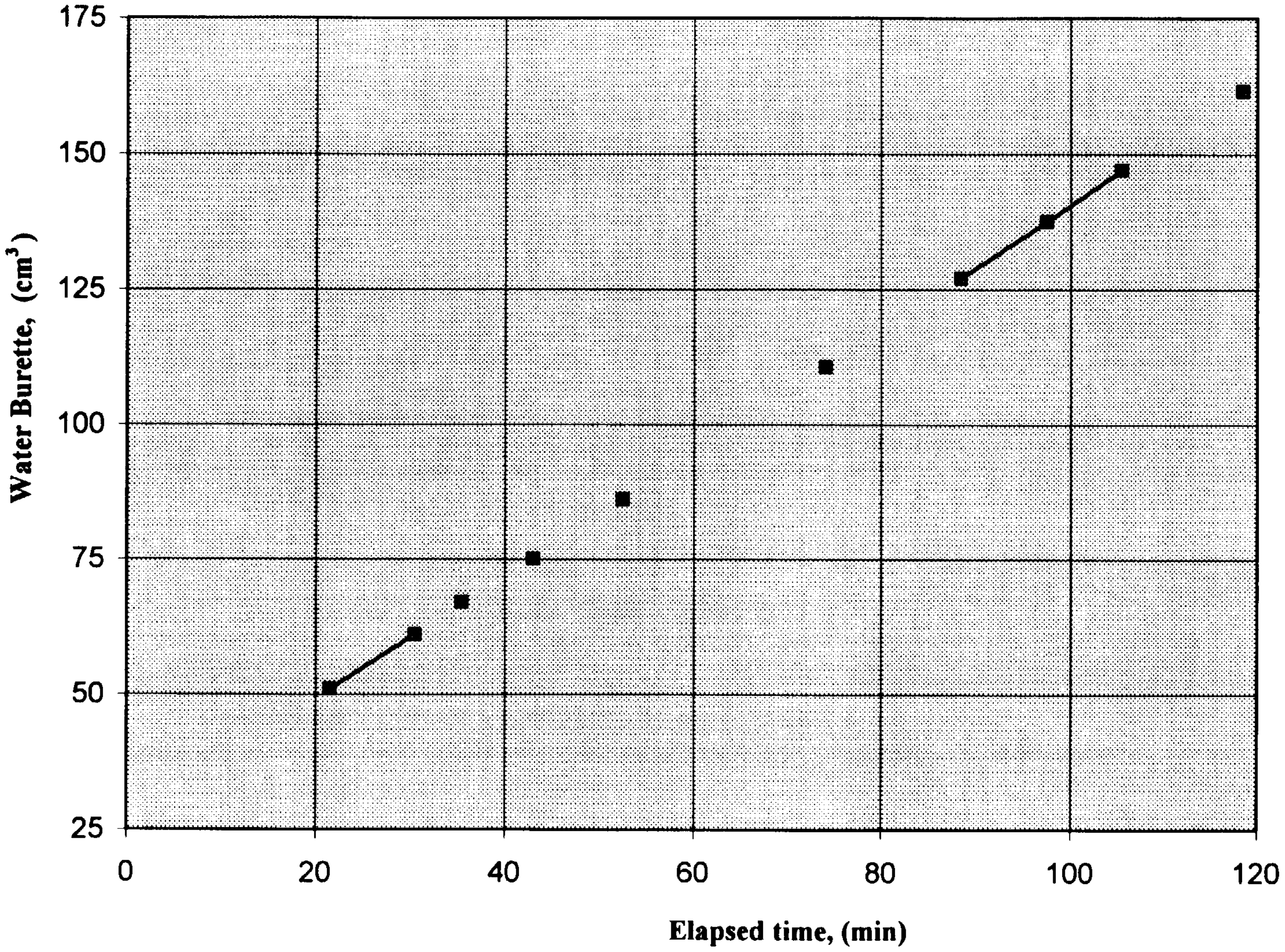
Run #24; O2 Enriched Steam Reformation of Referee Mix @ 1600°F - May 3, 1996

Gasified Mass of Referee Mix: 6.24 grams (956.9 milliequivs)

Time	Elapsed Time of Test (minutes)	Water Flow In Burrette Reading (cm³)	Water Flow In (cc/min)	Flow Circuit Sampled	Pressure P_3/P_5 (psig)	Helium Flow Rotameter Reading	Helium Flow flow (scc/min)	<—— Oxygen Flow ——> Rotameter Reading	Oxygen Flow flow (scc/min)	Oxygen Flow mequiv/ min	Gaseous Effluents Recovered <—— (millimoles / min) ——> H_2	O_2	N_2	CO	CH_4	CO_2	
											mmols min	mmols min	mmols min	mmols min	mmols min	mmols min	
2:05	0.00		bottom heaters & helium flow on														
2:20	15.00	43	1.23		100/96	38	128.99	-	-	-							
2:21	16.00		start O2 flow														
2:26:30	21.50	51	1.11		100/95	38	127.82	14	59.90	9.794							
2:35:30	30.50	61	1.20		100/96	38	128.99	14	60.44	9.883							
2:36:30	31.50		start water flow (stroke 0.100")														
2:40:30	35.50	67	1.07		101/98	38	131.32	14	61.54	10.062							
2:42	37.00		top furnace (No. 1) on														
2:48	43.00	75	1.16		101/97	38	130.15	14.5	62.44	10.210							
2:49	44.00			**GC (T2 = 160°C)**			129.46					0.7717	0.0262	0.0772	0.0062	1.5433	Gasifier
2:55	50.00			**Bag (T2 = 200-250°C)**			125.31					0.0397	0.0410	0.0052	-	1.3021	Reformer
2:57:30	52.50	86	1.14		101/97	37	123.58	14.5	62.44	10.210							
3:00	55.00			T2 = 517°C													
3:00:30	55.50			**Bag (T2 = 500-600°C)**			124.50					0.2696	0.0518	3.9284	3.1963	5.3212	Gasifier
3:05	60.00			T2 = 632°C													
3:06	61.00			**Bag (T2 = approx 650°C)**			126.18					0.0158	0.1536	0.2281	0.3162	16.711	Reformer
3:14	69.00			**Bag (T2 = approx 700°C)**			128.62					0.0196	0.0182	1.6111	1.9614	5.1415	Gasifier
3:19	74.00	110.5	1.15		101/97	38	130.15	14.5	62.44	10.210							
3:23	78.00			**GC (T2 = approx 740°C)**			130.15					0.0035	0.0330	0.1769	0.0094	6.2509	Reformer
3:33:30	88.50	127	1.15		101/97	38	130.15	14	60.99	9.973							
3:42:30	97.50	137.5	1.14		100/96	38.5	132.32	14.5	61.88	10.119							
3:50:30	105.50	147	1.14		101/98	38.5	134.71	14	61.54	10.062							
3:58	113.00			**GC (T2 = approx 740°C)**								0.706	0.064	0.016	0.001	0.128	Gasifier
4:00	115.00		O2 & furnaces shut off														
4:03:30	118.50	161.5	end run - system shut down														

Run #24: Steam Reformation of Referee Mix @ 1600°F

Note: carrier gas (helium) flow @ 132 scc/min



Appendix B

Experimental Data

RUN #1

Steam Reformation Data Sheet

Date: 12-8-95
Page: 1 of 1

Material Tested: CELLULOSE
Sample Weight: (AVICEL PH-200 Microcrys)
Crucible Tare: 25.74
Tare + Al2O3: 29.35
Tare + Al2O3 + Sample: 34.37
⇒ 5.02 g Cellulose

Set Temperatures:
Set Point #1: 649°C (1200°F)
Set Point #2: 760 (1400°F)
Set Point #3: 760
Ice Bath: 0

Trap Weights Gasifier:
Water Gross: -
Water Tare: -
Filter Gross: -
Filter Tare: -
Filter Pore Size: 8.0 μ

Trap Weights Reformer:
Water Gross: -
Water Tare: -
Filter Gross: -
Filter Tare: -
Filter Pore Size: 0.3 μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2 Rotameter	O2 Rotameter	Pressure (psig)	Comments
13:30	24.3	24.2	24.5	24.2	24.1	22	22	22	80	190	34	-	90	Gas Flow: 100 scc in 58 sec. !!
13:31	Furnaces on					-	-	-						
13:35						161	159	149						
13:36	45.4	25.3	-	26.9	26.9	-	-	-						
13:44	213.3	52.6	-	63.8	67.6	410	471	453	Furnaces off	-	Problems w/ Flow			Gas Flow: 100 scc in ____ sec.
13:50	303.2	95.6	-	108.0	112.8	388	451	416						
14:08	316.4	189.6	-	194.6	195.8	331	364	305	80		40			⇐ Furnaces on again 14:08
14:10	314.3													
14:12	344.3													Gas Flow: 100 scc in ____ sec.
14:15	359.3													
14:16	362.4	220.8	-	226.7	228.7	409	577	512	-	-	-			
14:18						408	653	582	84		40		(88)	
14:20	373.	171.7	-	216.8	245.1	-	-	-	-	-	-			
14:27	437.6	272.6	-	252.1	292.7	406	754	732	80		40		(88)	Gas Flow: 100 scc in ____ sec. 14:27 Cold Trap = 0°C
14:38	478.4	168. (?)	-	332.4	351.4	527	761	765	75		40		(90)	14:38 " " "
14:45	616.	408.7	-	384.	430.5	-	-	-	-		-			-
14:55	639.9	531.2	-	523.8	530.7	649	760	755	80		42			14:55 Cold Trap = 0°C
15:00	641.	543.2	-	543.	549.5	650	760	759	80		42			15:00 " " "
15:10	648.	572.6	-	579.3	577.4	647	760	756	75		42			Gas Flow: 100 scc in ____ sec. 15:10 Cold Trap @ 0°C
15:12	Furnaces off								-					
15:20	501.7	565.	-	595	576	607	678	604	74 water		40 N₂			15:20 Cold Trap @ 0°C
														Gas Flow: 100 scc in ____ sec.

15:00
15:05

Steam Reformation Data Sheet

RUN #1 (cont.)
Date: 10-12-96
Page: 2 of 2

Material Tested: ____
Sample Weight:
Crucible Tare: ____
Tare + Al2O3: ____
Tare + Al2O3 + Sample: ____

Set Temperatures:
Set Point #1: ____
Set Point #2: ____
Set Point #3: ____
Ice Bath: ____

Trap Weights Gasifier:
Water Gross: ____
Water Tare: ____
Filter Gross: ____
Filter Tare: ____
Filter Pore Size: ____

Trap Weights Reformer:
Water Gross: ____
Water Tare: ____
Filter Gross: ____
Filter Tare: ____
Filter Pore Size: ____

ch Back [illegible] Sample

Sample [illegible]

[illegible] Sample

(On line [illegible] Sample

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
10:53	656	578	580	579	-	648	760	758	75	127	0 ?		>100	Gas Flow: 100 scc in ____ sec.
11:00	627	515	565	566	-	648	759	761	75	107	40.5		90	▷ 10 cc in 11.9 sec → 50.4 cc/min Water Res @ 115 @ 11:01:00
11:11:30-11:18														
11:10	?	594	606.1	605.8	-	650	756	757	75.5	107	40		88	
11:12	-	619	622	624	-	650	762	762	75.5	107	39		89	Gas Flow: 100 scc in ____ sec. 127.5 cm3 on water @ 11:12:00 139@ 11:22:25
1124:														
11:25	(Switched R5 to Reformer) Upstream Helium pressure rises - problem apparently will 0.3 μ filter on reformer sample side instead of 8.0 μ filter on purifier side. i.e. Note discrepancies between P3 & P5 and water pressure rise. From here on differentiate P3/P5 for N2/O2 pressure													
														Gas Flow: 100 scc in ____ sec.
11:31	655	637	638	637	-	650	760	756	76.5	123	>0		~110/82	Gas Flow: 100 scc in ____ sec. Water 152 @ 11:32:10
11:39	Increase Helium source pressure to 120 psig													
11:41	~634	624.1	634	635.4	-	650	760	759	75.5	132.5	~10-30		~115/89	Water 165.5 @ 11:43
11:46														Gas Flow 100 sec in 2:14.5 min/sec
11:56:00											~30		~118/89.5	Gas Flow: 100 scc in ____ sec.
11:53	~641	642.9	644.7	645.2	-	649	760	763	76.5	134.				
11:56	water off (181.5 cm3 in Reservoir)													
12:02	Furnaces off													
12:04	650	649.0	649.1	648	-	641	742	722	-	-	>100		77/82	Gas Flow: 100 scc in ____ sec.

RUN #2

Steam Reformation Data Sheet

1027.0
976.5
50.5

841.2
~~888.2~~
853.5
68.7

Date: 1-10-96
Page: 1 of 2

Material Tested: CELLULOSE
Sample Weight:
Crucible Tare: 26.25 g
Tare + Al2O3: 29.85 (3.60 g 25-50 mesh)
Tare + Al2O3 + Sample: 34.90
→ 5.05 g Avicel 200

Set Temperatures:
Set Point #1: 649
Set Point #2: 760
Set Point #3: 760
Ice Bath: 0

Trap Weights Gasifier:
Water Gross: 1027.0 GRAMS
Water Tare: 50.5 grams
Filter Gross: 0.07 GRAMS
Filter Tare: 0.06 GRAMS
Filter Pore Size: 8.0 MICRON

Trap Weights Reformer:
Water Gross: 922.2 GRAMS
Water Tare: 68.7 GRAMS
Filter Gross: 0.29 GRAMS
Filter Tare: 0.10 GRAMS
Filter Pore Size: 0.3 MICRON

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
1:15 PM 1:20 ~~11:00 AM~~									110.5	188.5	(10 cc cyl MT @ t=0)			Gas Flow: 100 scc in _____ sec.
96 DAK PUMP 3:40 PM									65.5	Δ = 10 psig	50 → 100 cc/min		90 psig	Water Rate: 8 ml/9m 8 sec ⇒ 0.87 ml/min
96 8:40 AM	H2O CAL 6ML IN 5MIN-14.8sec 1.14ML/MIN													Gas Flow: 100 scc in _____ sec.
9:19 AM	5ML ON WATER RESERVOIR													
9:38 30 AM	H2O CAL 6ML IN 5MIN-19.7sec 1.13 ML/MIN 29 ML ON WATER RESERVOIR													
	supplemental data sheet: shows 1.14 ml (5 min 14.8 sec for 6 ml) 1.13 ml (5 min 19.7 sec " ")					} water flow								Gas Flow: 100 scc in _____ sec.
9:58	100 cc He in 52.2										40.5			water level @ 48 cc (drawn on reservoir)
turned on 10:00	24.6	22.6	22.4	22.4	–	77	72	73	75	Eldex 15 psig	(vent) 40.5	–	@ 90	Gas Flow: ~~100 scc in _____ sec.~~ 114 cc/min He
10:06 10:09-10:10	163.5	49.3	52.7	58.4	–	404	382	380	75	15	40.5		90	Water level @ 10:06.00 57 cc
flow → @ TC#1 10:11:18 sec = 200°C	/ Not up to pressure until									75 psi 90 psi	@ 10:14:18 @ 10:14:52			10:11:18: water level @ 63 cc
10:17	490	131.4	141.2	152.8	–	614	567	554	65.5	105	40.5		90	Gas Flow: 100 scc in _____ sec. 67 cc water
Sample (gasifier) 10:20-:23:45		–												
10:22	570.1	220.7	242.7	268.6	–	642	692	657	67.	105	40.5		90	
10:26	610.8	285.5	307.2	328.2	–	647	749	713	67	105	40.9		90	Water Res = 78 cc @ 10:28:40
sample (silica) 10:33-10:37:20														Gas Flow: 100 scc in _____ sec.
10:34:30	563.	453.9	456.9	465	–	651	766	758	67.5	105	40.5		90	Water Res = 87 @ 10:36:45
~~10:38~~														10:38! Switched sample to Reformer
10:45	650	533.4	538.2	537.5	–	651	753	760	72.	127.0	<<40		~107	
10:51									75.	126.0 (plugging of gas line)	<<40			Water Reservoir @ 103 cc @ 10:51

Reaction Time 10:20 (~160°C) to 11:56 (96 min)

Helium flow 4:26 sec for 100 cc

.1 of 8.0 H run FILTER in REFORMER = 0.07 grams

RUN #3

Steam Reformation Data Sheet

reweighed to 977.4

1:5? sample 1
2:3? sample 2

Date: Thur 1-~~28~~ 31 96
Page: 1 of ___

Material Tested: CELLULOSE (AVICEL PH-200)
Sample Weight:
Crucible Tare: 30.94
Tare + Al2O3: 35.61
Tare + Al2O3 + Sample: 41.40

3561
3705
3561
1.44

AFTER TEST TARE + Al2O3 + SAMPLE = 3705 g.

Set Temperatures:
Set Point #1: 371 °C (700 °F)
Set Point #2: ~~871~~ 760 °C (1400 °F)
Set Point #3: ~~871~~ 760 °C "
Ice Bath: 0 °C

Trap Weights Gasifier:
Water Gross: 1022.7
Water Tare: 976.5
Filter Gross: ___
Filter Tare: ___
Filter Pore Size: ___

Trap Weights Reformer: — weighed 2/2/9?
Water Gross: 897.5
Water Tare: 853.5
Filter Gross: 44.0 → 43.40
Filter Tare: 0.07 g
Filter Pore Size: ___

38.87 sample
14.53 "
43.40

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2 Rotameter	O2 Rotameter	Pressure (psig)	Comments
10:30 AM	Eldex micrometer @ 0.110": Water Rotameter					@ 82; 10 cc in 7:52.4 min:sec								Gas Flow: 100 scc in _____ sec.
	0.100": " "					@ 81.5; 8:23.7 "			"; P_{H_2O} (to 4-6) = 30 psig					
1:15 PM	Water 1.20 cc/min													
1:20 PM	Eldex " " @ 0.100": Water Rotameter					@ 81; 10 cc in			; P_{H_2O} (to 4-6) = 31 psig					
1:30	HELIUM 100 cc/min													
1:34	FURNACES ON @ 23°C													Gas Flow: 100 scc in _____ sec.
1:35	22.3	24.0	23.9	24.0	—									
1:36	24.4	25.6	24.0	24.6	25.0 24.2									
1:40	87.7	30.8	30.7	33.1	101.7 92.5	(4) 327	313	311						
1:44:30	35.4	63.6	74.4	75.1										
1:45	Eldex @ 0.100": Water Rotameter					@ 81; 10 cc in 8:28.6			min:sec; P_{H_2O} (to 4-6) = 31 psig (1.18 cc/min)					(1:45) Water Burette = 24 cc
1:49	292.	84.7	85.0	90.2	- -	364	505	502						Gas Flow: 100 scc in _____ sec.
	387 (11)	403	291.	212.	67.8									
1:53		115.9				371	623	601						
1:53+	343.9	119.1	118.3	122.5										
	564	567	341	454	321 89.9									
1:55		126.8												(1:56) Water Burette = 37 cc
1:59		143.5	2:00 PM											Gas Flow: 100 scc in _____ sec.
2:00	397.7	155.7	150.9	166.7	— —	371	748	696						
	720.2	721.6	482.2	621.1	454.6 121.9									
2:04		176.2												(2:07)
2:04:50	406.7	187.4	184	198.9		371	755	743						Water Burette = 48.5
	735.4	742.3	550.1	688.7	511.7 140.9									
2:07		201.7 ← Water into circuit (gasifier)												Gas Flow: 100 scc in _____ sec.
2:09	417.4	216.9	214.6	228.2		372	760	752	(72)	(90)			(90)	
	736.9	746.9	583.1	714.3	530.2 149.0									
2:11		236.3												
2:12-213	424.4	241.3	247.5	256.2		374	760	759	(75)	90	(28)		(95)	
	736.8	750.2	603.4	727.4	532.7 152.2									Gas Flow: 100 scc in _____ sec.
2:14		270.2											(89)	
2:15-16	393.7	274.9	273.3	279.6		377	760	760	75.5	90	28			
	736.3	751.9	617.4	732.3	535.8 153.4									
2:18*		280.8												
2:21														(2:21) WATER BURETTE = 65

sifier → 2:18

2:08 (1st water [illegible]) to 3:45 ⇒ 97 min

Run #3 (cont)

Steam Reformation Data Sheet

Date: Wed 1-31
Page: 2 of 2

Material Tested: ____
Sample Weight:
Crucible Tare: ____
Tare + Al2O3: ____
Tare + Al2O3 + Sample: ____

Set Temperatures:
Set Point #1: 371 °C
Set Point #2: 760 °C
Set Point #3: 760 °C
Ice Bath: 0 °C

Trap Weights Gasifier:
Water Gross: ____
Water Tare: ____
Filter Gross: ____
Filter Tare: ____
Filter Pore Size: ____

Trap Weights Reformer:
Water Gross: ____
Water Tare: ____
Filter Gross: ____
Filter Tare: ____
Filter Pore Size: ____

	Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2 Rotameter	O2 Rotameter	Pressure (psig)	Comments
asifier g Sample}	2:24-2:31														Gas Flow: 100 scc in ____ sec.
	2:26		298.9												
	2:28		311.1												
	2:30 }	426.7 734.	315. 755.2	313.1 645.2	312.1 738.2	526.6 150.8	388	760	763	75	88	28		89	Water Burrette = 71.5 @ 2:27 PM " " 77.5 @ 2:31 PM
tch to ormer →	2:31 *		316												
	2:33		332.9				392	760	766	75	88	28		89	Gas Flow: 100 scc in ____ sec.
		429.9	331.9												
	2:37	429.8 731.1	336.9 755.8	323.4 660.8	340.9 740.7	526.3 183.	399	760	760	76	88	28		89	Water Burrette = 88 @ 2:40 PM Water Burrette = 90 @ 2:42:10
rmer sample}	2:42-248														
	2:44-		366.4												Gas Flow: 100 scc in ____ sec.
	2:44-246	426.6 729.6	358.5 756.6	351.8 669.1	341.1 740.4	524.3 185.3	404	760	762	76	88	28		89	
	2:49		354.0												Water Burrette = 97 @ 2:48
Reconnect GC	@ 2:49:50														
	2:54	433. 729.1	366.1 758.3	369.1 677.8	372.9 743.0	524.4 186.0	414	760	766						
rmer ↔ ample	2:56:15*									76	88	28		89	Gas Flow: 100 scc in ____ sec. Water Burrette = 106.5 @ 2:56
	2:58 Switch back to Gasifier **														" " = 109.5 2:59
	3:01		396.7												
	3:01-3:03	447. 728.8	751.9	401.6 682.0	405.6 748.4	526.1 177.2	419	760	764	75.5	86	28		87	
ier Bag} mple	3:05-3:15														Gas Flow: 100 scc in ____ sec.
	3:08	459.6 729.3	412.4 760.9	3:08 418.4 685.3	415.7 750.1	524.3 163.6	425	760	760	75	88	28.5		89	Water Burrette = 117 @ 3:06:30
	3:18 3:19:3	470.3 730.4	417.6 762.4	423.3 689.8	420.7 751.7	522.7 156.1	433	760	765	75	87.5	28		88.5	Water Burrette = 126.5 @ 3:15 PM " " = 133.5 @ 3:21 PM
	3:25	473.4 730.6	418.3 762.9	430.4 692.9	430.7 751.5	521.1 154.3	439	760	765	75	86.5	28		89	Gas Flow: 100 scc in ____ sec. Water Burrette = 140 @ 3:27 PM
ier ↔ mple	3:31 **														
	3:32-	465.5 730.7	441.4 763.7	441.3 695.6	440.2 752.8	521.5 153.1	444	760	765	75	86.5	28		87	" " = 148 @ 3:33 PM
	3:45-3:45	468.0 731.0	452.0 764.6	445.2 700.4	449.1 755.2	522.1 153.1	452	760	756	75 115.	860	28		88	

⇒ Furnaces & Water off @ 3:45:08

4:00-4:01 483.5 469.3 469.5 468.7 451 668 585 (Helium off @ 4:05 PM)

Water Burrette = 162.5 @ 345:08 PM

RUN #3a

Steam Reaction wi Carbon @ 1200°F

Steam Reformation Data Sheet

Note: overflow of water @ end of run

Date: ~~2-2-96~~ 2-7-96
Page: 1 of 1

Material Tested: Cellulose Char @ 1200°F
Sample Weight:
Crucible Tare: ______
Tare + Al2O3: 35.61
Tare + Al2O3 + Sample: 37.05 → Start 1.44 g
36.34 → Fin 0.73 g

Set Temperatures:
Set Point #1: 649 °C
Set Point #2: "
Set Point #3: "
Ice Bath: 0 °C

Trap Weights Gasifier:
Water Gross: 1053.6
Water Tare: 976.8
Filter Gross: ~~0.6~~ ~~1.8~~ g {0.023 pre drill / 0.06 g
Filter Tare: ______
Filter Pore Size: ______

Trap Weights Reformer:
Water Gross: 936.5
Water Tare: 853.9
Filter Gross: ~~0.7~~ g 0.07 g
Filter Tare: ______
Filter Pore Size: ______

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~-He Rotameter	O2 Rotameter	Pressure (psig)	Comments
1:15 PM									96	ΔP=42 psi	34 @ 90 psi*		@1:2	Gas Flow: 100 scc in 53.5 sec. 112 scc/min
Start ⇒ 1:34 PM	Water burette @ 7. – (all heaters on)												@ 1:15	Water ≈ 10 cc in 8:22.1 ⇒ 1.195 cc/min
1:32	26.6	26.6	26.6	26.6										
	26.8	26.7	25.9	26.1 26.0	25.2	73	75	72	96		34.			
1:35		29.3												
1:41	169.5	81.0	83.1	87.5										Gas Flow: 100 scc in _____ sec.
	221.4	275.2	133.5	221.4 149.1	56.7	481	447	438	96		30.5 @ 90 psi			Water = 5 cc in 4:10.3 ⇒ 1.20 cc/min
1:54	622.3	275.4	276.1	304.3										
	624.1	620.2	364.2	591.2 411.0	109.4	650	644	642	95.5		34. @ 90 psi*			
1:56	Water 36.0 on burette													
Water Experiment Sample ⇒ 2:00 PM	639.1	418.9	424.	429.3										Gas Flow: 100 scc in _____ sec. Water burette @ 42
	638.	631.7	422.4	627.8 440.1	113.7	646	649	650	95. –		34. @ 90 psi			
Sample ⇒ 2:09,30 to 2:15.30														
2:10	616.4	505	504.6	507.6										
	640.5	631.8	443.3	639.4 435.7	113.4	649	649	648	94.5		33 @ 90 psi			
2:20	617.8	558.2	559.5	559.8										
	641.8	631.3	456.5	648.3 432.3	109.7	647	649	648	94.5		34 @ 87.5			Gas Flow: 100 scc in _____ sec. Water burette @ 65.
2:30	624.5	584.8	584.8	585.8										
	642.3	630.9	467.1	650.3 425.1	108.4	650	649	649	94		31 89 psi			2:30:15 Water burette @ 76
Sample ⇒ 2:32:35														
2:45	626.4	609.6	612.6	609.7										
	643.7	632.2	480.1	656.1 424.3	107.3	649	649	649	94	@ 1[illegible]0 psi	31 @ 89 psi			2:46 Water Burette @ 94.
Sample ⇒ 2:46-2:55														Gas Flow: 100 scc in _____ sec.
3:00 PM	634.6	630.2	630.4	630.8										
	644.1	633.2	490.1	655.6 419.3	107.4	649	649	649	93.5	@ 130 psi	33 @ 89 psi			3:01:52 Water Burette 112. –
3:12 PM	634.2	642.7	642.8	642.1										
Sample ⇒ 3:16 PM	645.4	635.2	499.2	660.3 421.5	106.8	647	649	649	94	@ 130 psi	33 @ 89 psi			3:17:20 Water Burette @ 130.
3:27	636.9	642.6	643.8	642.4										
	645.7	635.8	504.2	657.6 418.8	106.3	648	649	648	93.5	@ 128 psi	30.5 @ 88.5 psi			Gas Flow: 100 scc in _____ sec.
3:35 –	~~Continued water flow~~													
	General Shut down			151.5 @ 3:35:20		water overflowing into bags								Comment: broke into effluent line preparatory to taking GC bag sample & save water

* Referenced P_S reading

2:01 (start water @ T = 419°C) to 3:35:20 ⇒ 94:20 min

Run #4 (cont)
Steam + O_2 Reduction of Cellulose @ 1200°F

Steam Reformation Data Sheet

Date: 2-9-96
Page: 2 of 2

Material Tested: ____________
Sample Weight:
Crucible Tare: ____________
Tare + Al2O3: ____________
Tare + Al2O3 + Sample: ____________

Set Temperatures:
Set Point #1: ____________
Set Point #2: ____________
Set Point #3: ____________
Ice Bath: ____________

Trap Weights Gasifier:
Water Gross: ____________
Water Tare: ____________
Filter Gross: ____________
Filter Tare: ____________
Filter Pore Size: ____________

Trap Weights Reformer:
Water Gross: ____________
Water Tare: ____________
Filter Gross: ____________
Filter Tare: ____________
Filter Pore Size: ____________

g Sample

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig) P_5	Comments
3:33 –	3:36:30	Oxy Sample of gasifier only												Gas Flow: 100 scc in _____ sec.
3:31	?	638.0 – 640,	640.2			648	759	756						
	743.3	752.3	644.0	765.5	571.8	153.5			73	127	34.5	38	P_5 = 89	P_4 = 98 P_3 88 P_2 = 100 Burette 104. @ 3:33 PM
3:41	550.7	638.0 – 639.5	641.7											
	743.4	752.8	647.8	758.7	569.7	146.5	649	760	763	73	127	35	39	89	P_4 = 98, P_3 = 88, P_2 = 100
3:43	Water Burette @ 115.													Gas Flow: 100 scc in _____ sec.
3:44	Shut off water & furnaces					Water Burette @ 117. / 116.5								
~~[illegible]~~														
3:50	3:52 O_2 bled down – O_2 flow stopped													
3:52	682.6	643.1 – 642.0	641.5											
3:54:3	692.7	698	591.0	651.7	495.3	112.5	621	697	630	–	–	35	–	87	Gas Flow: 100 scc in _____ sec. P_4 = 88 P_3 = 86 P_2 = 98
4:05	584.2	644	611.7	615.8	606.1	601.6	~~606.1~~ 461.1	~~607.6~~ 454.8	281.2	75	–	35	–	83	P4 = 97 P3 = 84 P_2 = 95
4:20	535.4	583.2	583.7	583.3										
	533.1	521.1	378.2	373.0	194.1	54.8	538	545	409	–	–	35	–	89.5	Remarks: 2½ minutes to read line [illegible]
4:31	497.6	553.6	554.0	553.6			510	499	360	–	–	35		89	
	479.1	462.2	319.6	299.0	147.6	48.0									Gas Flow: 100 scc in _____ sec.
4:40	423.8	525.1	524.9	524.2			481	458	314						
	432.5	411.7	274.3	248.8	117.6	43.1				–	–	35		90	
	Helium Flow off @ 4:43 PM														
														Gas Flow: 100 scc in _____ sec.
														Gas Flow: 100 scc in _____ sec.

RUN #4
Steam + O_2 Reduction of Cellulose @ 1200°F **Steam Reformation Data Sheet**

Sample 1 = 23.66
Sample 2 = 25.84
49.?

Date: 2-9-96
Page: 1 of 2

Material Tested: Avicel PH 200
Sample Weight: FMC Lot No. M502C
Crucible Tare: 27.40 g
Tare + Al2O3: 31.46
Tare + Al2O3 + Sample: 36.88
Final wt (2-12-96) ⇒ 31.39 g

Set Temperatures:
Set Point #1: 649 °C (1200°F)
Set Point #2: 760 °C (1400°F)
Set Point #3: 760 °C "
Ice Bath: 0 °C

Trap Weights Gasifier:
Water Gross: 1026.5 (est)*
Water Tare: 976.5
Filter Gross: 0.06
Filter Tare: 0.06 g
Filter Pore Size: 8 µ

Trap Weights Reformer:
Water Gross: ~~924.6~~ 896.7
Water Tare: 853.5
Filter Gross: 0.06 g
Filter Tare: ~~0.6~~ 0.06 g
Filter Pore Size: 8 µ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)		T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig) P_3	Comments
11:20												O_2 cal	40 @ 90 psig →		Gas Flow: 100 scc in ____ sec. 100 cc in 34.5 173.91 scc/min
													31.5 ~~30~~ " " →		56.2 106.76
1:34 PM												He cal	33 @ " " →		100 cc in 1:06.0 90.91
												H_2O cal	540 cc @ 58 psi →		540 cc in 4:08.2 1.2047
1:40 PM											O_2	+ He cal	(40 & 33)	90 psi →	100 cc in 0:21.0 & 20.8 285.7 288.5
1:48 PM	23.5	26.3	26.2	26.1			24	23	24	-	-	33	-	90	Heat on @ 1:48 PM
	23.9	24.6	24.5	23.7	23.8	23.8									Gas Flow: 100 scc in ____ sec.
1:56 PM	117.3	33.0	33.7	40.9 (@ 1:55:10)			301	288	288	76.5 (initial)	(57)	33.5	-	90	P_3 @ 90
	135.6	137.9	100.6	101.1	86.6	41.8	514	482	477						
~~2:00~~	~~[illegible]~~														
2:02	285.5	128.1	134.8	146.7											
2:02:30	384.4	402.2	245.6	321.0	250.9	72.9				76 76	57	34		90	P_3 @ 90 P_2 = 100
2:09	593.3	152.1	157.4	198.0											
	587.1	609.2	386.4	527.2	407.3	104.1	642	653	626	76.5	57	34	-	90	Gas Flow: 100 scc in ____ sec.
2:10:30	8 on water burette														Water 1.0 @ 2:05 PM
2:12 →	10 " " "														
2:16	635.8	322.4	327.2	395			647	760	736						
	743.	745.6	[illegible] 535.7	700.9	558	159.8				73.5 @	127	34	-	90	Water 17.5 @ 2:19 PM
2:22	O_2 on Take GC w/ Steam Flow only (of reformer)									73	125	34	40	90	P_3 = 99 P_2 = 99
2:24	595.5	286.8	330.6	397.7			650	761	756						Gas Flow: 100 scc in ____ sec.
	747.4	748.5	587.5	740.4	591.8	195.1									
2:25:44	Switched selector back to gasifier only														
2:28	588.9	637.9	626.3	556.1			648	761	762						
	747.9	751.9	594.4	748.1	593.6	168.4				73.5		34	38.5	90	Water @ 31 @ 2:30:16 P_2 108
2:30:30	gasifier ~~[illegible]~~ only to 2:33:00														
2:34	615.4	650.	646.5	594.8											Gas Flow: 100 scc in ____ sec.
	747.4	750.8	604.4	750.9	585.9	156.6	649	760	766	73	@ 128 psi	34	40	89	Burette @ 39. 2:36 PM P_4 = 98; P_2 = 100
2:39	620	692	666.6	608.4											
2:48	?	631.0	644.4	614.7			650	760	758	73	@ 128	34	39	90	Burette @ 53.5 2:49 PM
	745.8	749.9	618.2	757.7	577.3	147.2									
2:53:30	GC sample of flow from gasifier only														Burette @ 63.5 @ 2:59 PM
3:00	switch to flow from gasifier + reformer; Water Burette @ 66.														Gas Flow: 100 scc in ____ sec.
3:05-3:0?	of gasified + reformer effluent														
3:09	608.4	627.5	627.1	626.2			650	760	764	73	127	34	38	89	Burette 77.5 @ 3:11 PM P_4 = 98 P_2 = 100
	743.8	749.3	636.4	765.	571.4	168.7									
3:20	635.6	626.8	627.2	631.5											
	743.4	749.5	642.2	762.6	568.7	170.4	648	760	765	74	127	34.5	39	89	Burette 89 @ 3:21:30 P_4 = 99 P_2 = 100 P_3 = 99

173.91
90.91
264.8

Heat on @ 1:48 PM

1 Sample

⇒ 3:27:20 GC sample at flow from gasifier + reformer
3:28 Switch back to gasifier only

*Note: Acetone wash produces brown tar soln.

Run #5
Steam + O_2 Reduction of Cellulose

Steam Reformation Data Sheet

Maintain Gas flow
Start Water @ T_1 = 200°C

Date: 2-13-96
Page: 1 of __

Material Tested: Avicel PH 200
Sample Weight: FMC Lot No M502C
Crucible Tare: 27.12 grams
Tare + Al2O3: 31.36
Tare + Al2O3 + Sample: 37.17
2/19/96 After Run (31.52 grams) Briquette Wt = 0.66 g

Set Temperatures:
Set Point #1: 760°C (1400°F)
Set Point #2: 760 "
Set Point #3: 760 "
Ice Bath: 0°C

Trap Weights Gasifier:
Water Gross: 993.7
Water Tare: 976.6 g } 17.1 g
Filter Gross: 0
Filter Tare: 0.06 g
Filter Pore Size: 8 μ

Trap Weights Reformer:
Water Gross: 886.9 g
Water Tare: 853.6 g } 33.3 g
Filter Gross:
Filter Tare: 0.055 g
Filter Pore Size: 8 μ

Purple cast & strong napthalene odor

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
2:10 PM 2:22PM										P_5 ↓	~~He ~ 137 cc/min @ 40.5~~ O_2 ~ (~~-137)~~ = 75 cc/min @ 16.5 Water: 10 cc in 8:23.4 = 1.19 cc/min @ 76			Gas Flow: 100 scc in _____ sec. P_5 = 90 psig P_3 = 90 P_4 = 0 P_2 = 98.5 } @ 1:30 PM 2-14-96
1:38 PM 1:45 1:49.50 1:54	25.5 28.2 67.1 68.2 165.4	25.6 29.9 27.3 85.6 43.4	26. 28.6 27.2 57.6	25.4 27.0 27.3 54.7	26.9 24.7 @ 50.2 32.6	23 1:42 PM 247	21 244	23 241	77	58	He = 128 cc/min @ 40 39.5	O_2 = (193-128) = 65 @ 14 13	@ 90 psig	Gas Flow: 100 scc in _____ sec. P_1 = 57 1:42 PM Water Burette @ 16 cc P5 P_3 = 90 P_4 = 97 P_2 = 99
1:58 PM 2:04 PM	247.2 362.3 571.4 549.2	108.7 406.8 167.9 570.0	119.6 201.9 169.3 308.7	132.3 290.7 201.5 466.7	230.7 71.0 365.6 95.1	544 667	511 630	504 604	75.5 75	125 89	40 40	13 13		Gas Flow: 100 scc in _____ sec. 1:55 PM Water Burette @ 24.2 cc 30. P_4 = 97 P_3 = 89 P_5 = 89 P_2 = 99 125 psig Water Burette = 36 @ 2:05:20 P_4 = 97 P_3 = 89 P_5 = 98.5, P_1 = 125
⟹ 2:10 PM 2:15:30 – 2:17:30	T_2 = 200°C (GC of Gasifier @ 2:09:25) Switch flow to Reformer 724.0 733.5	295.8 744.7	303.8 481.7	409.4 650.8	528.7 139.8	756	750	724	75	127	40	13	90.5	Gas Flow: 100 scc in _____ sec. Water Burette 43.5 @ 2:11:40 P_4 = 98 P_3 = 99 P_2 = 99 P_1 = 126
2:15 PM 2:16:30 2:20 2:30 2:32	744.1 747.7 721.4 750.0	540.3 759.5 609.0 711.3 762.7	548.3 557.8 708.2 615.4	538.0 717.7 710.4 747.6	588.2 176.6 592.6 178.2	756 761	758 760	750 757	75 75.5	127 123	40 40.5	13.5 15	90 84	Gas Flow: 100 scc in _____ sec. P_4 = 97 P_3 = 90 49 @ 2:16:36 Water Burette Water Burette @ 63.2 cc P_4 = 89 P_1 = 117 P_3 = 72 P_2 = 74
2:37:30 2:40 2:42 2:43 2:48:30	Pressures still dropping 727.0 724.7	680.1 735.7	702.3 603.0	702 688.4	P_5 = 49.5 # P_5 = 39.5 P_5 = 29. 524.2 135.9	T_2 = 678.6 T_2 = 682.4 P_5 = 21 @ 2:47,	(All furnaces off)		P_1 = 60,	P_2 = 25,	P_3 = 23,	P_4 = 26		Gas Flow: 100 scc in _____ sec. Tried to sample reformer stream @ P_5 ≈ 15 psi
2:52	661.1 671.2	678.4 681.5	667.8 543.9	689.3 596.6	428.0 106.3	688	675	600			100	47	P_5 = 15	Water Burette @ 2:58:20 = 91.5 " " @ 3:03 = 101.6 cc Water off

-14-96
urnaces } on
ater Flow @ 1:55
ifier @2:08:25
09 ~ 2:10
rmer
g Sample

RUN #6
Steam Reduction of UREA

Steam Reformation Data Sheet

full @ 1055.5g (test only)
full @ 949.0g

Date: 2-26-96
Page: 1 of 2

Material Tested: UREA
Sample Weight:
Crucible Tare: 26.84
Tare + Al2O3: 30.48
Tare + Al2O3 + Sample: 40.93
{UREA Baker anal. Lot E05336 4204-01 Dated 8-7-92 (NS 606)

Set Temperatures:
Set Point #1: 760°C (1400°F)
Set Point #2: ↓
Set Point #3: ↓
Ice Bath: 0°C

Trap Weights Gasifier:
Water Gross: 1043.7g
Water Tare: 976.5 (67.2g)
Filter Gross: 0.06g
Filter Tare: 0.06
Filter Pore Size: 8μ

Trap Weights Reformer:
Water Gross: 900.8 ~~928.7~~g
Water Tare: 853.6
Filter Gross: 0.06g
Filter Tare: 0.06
Filter Pore Size: 8μ
(47.2g)

2-27-96
~~2-26-96~~

art wi
way valve
Reformer
osition

~~[illegible]~~ON

ENAKES ON

t ON @
200°C

#1
#2
#3

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
8:46 AM									77 10 cc in 8:35.9 → 1.16 cc/min	68 psi (to atm)	40	10.5		Gas Flow: 100 scc in ____ sec. He: 100 cc in 1:00.5 → 99.2 @ 89 psia (P5) He + O2: 100 cc in 36.9 → 163.0 @ 90 " → O2 = 63.8 scc/min {Avg of 4 158 cc/min − 99.2 ⇒ 58.8 s/min
9:~~15 TM~~	~~264~~ ~~243~~ ~~21.3~~													Gas Flow: 100 scc in ____ sec.
9:19	25.1	25.8	25.8	27.2		23	22	23	77	62 to amb	40	10.5	90	P_4 = 97 O2 P_3 = 90 He P_2 = 98
	24.2	24.1	24.0	23.8	23.5 23.7									
9:30	25.2	25.7	25.6	25.4					77.5	63	39.5	10	90	97 90 98
9:33	38.4	25.9	25.8	26.0		137	138	139	78	65	40	10	91	Gas Flow: 100 scc in ____ sec. 9:32 AM Water Burette 11. cc
	42.1	55.8	39.6	38.5	35.2 28.0									
9:38	166.4	38.5	39.8	49.2		387	367	369						
9:39	Water ON — Water Burette @ 20													
9:40	238.5	54.2	55.5	70.3										
	285.4	345.8	174.8	218.4	177.7 66.2	487	457	451	76	153	40	9.5	90	Gas Flow: 100 scc in ____ sec. P_4 = 98 P_3 = 90 P_2 = 99 Burette 22.5
9:44	G.C. sample of Reformer Effluent													
9:47 7	switch selector to Gasifier "													
9:50 - 8	G.C. Bag Sample of Gasifier													
9:50 - 53	645.5	254.7	262.6	283.1		721	691	646						
9:53	656.9	681.5	431.8	559.8	450.4 135.6				77	153	40	9	89	Gas Flow: 100 scc in ____ sec. Burette = 34.5 @ 9:54:50 Burette = 41 @ 9:57:25 P_3 = 90 P_4 = 98 P_2 = 98
9:56 9	729.9	418.0	409.5	413.8		763	754	740	77	153	P_3 = 90 40	P_4 = 97 9	P_2 = 98.5 90	
	743.8	762.9	551.4	618.8	560.4 113.3									
9:59:40 10 - 10:06	Bag sample of Reformer													
10:02	742.6	546.6	546.4	549.8		763 756	760	760 755	77	153	40	8.5	P_5 = 89	Gas Flow: 100 scc in ____ sec. Burette @ 38 @ 10:05
	762.3	768.9	619.2	731.5	602.4 190.5									
10:10 - 10:15	Bag Sample of Gasifier													
10:12	745.7	636.6	637.2	636.7										
	753.1	771.5	652.4	743.7	603.0 177.5	762	760	761	77	153	40	8	88	P_3 = 87 P_4 = 94 P_2 = 99; Burette = 58 @ 10:13:30

Some Pressure Oscillation between 86 to 90 psi on short ~20 sec time constant. Pressure rise from 86 to 90 in c.a. 2 sec!!

RUN #6 Cont
Steam Reduction of UREA

Steam Reformation Data Sheet

Date: 2-27-96
Page: 2 of 2

Material Tested: UREA
Sample Weight:
Crucible Tare: ____
Tare + Al2O3: ____
Tare + Al2O3 + Sample: ____

Set Temperatures:
Set Point #1: ____
Set Point #2: ____
Set Point #3: ____
Ice Bath: ____

Trap Weights Gasifier:
Water Gross: ____
Water Tare: ____
Filter Gross: ____
Filter Tare: ____
Filter Pore Size: ____

Trap Weights Reformer:
Water Gross: ____
Water Tare: ____
Filter Gross: ____
Filter Tare: ____
Filter Pore Size: ____

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
10:18:10 to 10:18:3	*G.C. Sample of Reformer Effluent									P_1				Gas Flow: 100 scc in ____ sec.
10:21	752.2 751.9	640.7 770.2	689.3 672.2	689.2 752.2	597.6 183.5	759	760	758	77	153	40	9.5	89.5	P_3 = 88.5 P_4 = 97 P_2 = 98 Burette He = 69 @ 10:23
10:29	Switch Valve back to Gasifier													Gas Flow: 100 scc in ____ sec.
10:30	743.8 750.3	723.4 771.2	723.4 683.2	722.6 759.4	596.1 169.3	758	760	756	77	153	40	14 ↕ *	86-90	P_3 = 87 P_4 = 96 P_2 = 95 @ 10:35 Burette He = 83.8
10:40	O_2 rises to 14 on rotameter as P_5 drops to 84 psia													
10:42	750.4 749.6	740.4 771.2	740.7 692.3	740.4 763.0	592.6 161.7	762	760	757	77	153	40	10	86-89	Gas Flow: 100 scc in ____ sec. P_3 = 86 P_4 = 96 P_2 = 98 @ 10:45:30 Burette = 96.0
10:50	744.9 749.3	747.9 771.5	747.3 697.4	747.8 763.2	596.8 159.3	760	760	761	77	153	40.5	14	** 84	P_3 = 88 P_4 = 97 P_2 = 97 @ P_5 = 89**
10:55	Sample of Gasifier flow to G.C.													Gas Flow: 100 scc in ____ sec. @ 10:55 Burette = 107.5
10:57	O_2 off but continued flow as regulator depressurizes													
11:00	751.2 749.3	754.0 771.9	753.7 701.1	753.6 767.6	589.5 157.4	759	760	757	77	153	40	12	86	P_3 = 88 P_4 = 97 P_2 = 98 @ P_5 = 88** **(pressure bet 83-88)
11:11:30 11:19 11:20 11:21	Water back to Reformer until O_2 peters out – O_2 exhausted water flow shut off – Burette = 135.4 Furnaces shut down – Let Helium continue to flow until 1:00													Gas Flow: 100 scc in ____ sec.
														Gas Flow: 100 scc in ____ sec.

*Note O_2 rotameter fluctuated bet 7.5 to ~12 out of phase with pressure swings

RUN #7
Steam Reformation of UREA

He:

Steam Reformation Data Sheet

Date: 2-28-96
Page: 1 of ___

Material Tested: UREA - Baker Lot 4204-01 dated 8-7-92 Reagent Grade
Sample Weight:
Crucible Tare: 26.26
Tare + Al2O3: 32.44
Tare + Al2O3 + Sample: 42.43
7.99g

Set Temperatures:
Set Point #1: 760°C (1400°F)
Set Point #2: 871 (1600°F)
Set Point #3: 871 "
Ice Bath: 0 32°F

Trap Weights Gasifier:
Water Gross: 976.3*
Water Tare: 976.6
Filter Gross: 0.06 g
Filter Tare: 0.06
Filter Pore Size: 8μ

Trap Weights Reformer:
Water Gross: 884.7*
Water Tare: 853.6
Filter Gross: 0.06 g
Filter Tare: 0.06
Filter Pore Size: 8μ

Stink of NH_3 both filter & trap filter [illegible] [illegible]

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2 /He Rotameter	O2 Rotameter	Pressure (psig)	Comments
~~2:36~~	~~24.4~~ #1 TC out													Gas Flow: 100 scc in _____ sec.
2:37	–	24.7	24.6	24.5		24	23	25						
	25.6	25.7	25.7	25.4	25.4 25.4				73	61	40 ✓	3.5 ✓	90 ✓	P_4=98 P_3=89 ✓ P_2=99 ✓
2:40	FURNACES ON ✓													
2:41									74					2:41 ✓ Water Burette = 3.5 cc ✓
2:43	–	24.8	24.8	24.9		147	152	148						Gas Flow: 100 scc in _____ sec.
2:44	44.9	47.2	43.4	42.1	37.6 28.9				74.5	60	40 ✓	3.5 ✓	91 ✓	P_4=99 P_3=90 P_2=100 2:45 Water Burette = 8.5 cc
2:50 ✓	WATER INTO SYSTEM													2:50 ✓ Water Burette = 16.5 ✓
2:50:30	–	47.8	47.9	58.0										
~2:52	243.9	272.8	160.9	193.8	155.4 56.2	450	432	426	73.5	143	40 ✓	3.0 ✓	91 ✓	P_4=99 P_3=89 P_2=100
2:55 ~~3:00~~	GC Sample #1 - Reformer Only													Gas Flow: 100 scc in _____ sec.
2:55 ~~3:00~~	–	164.1	166.1	163.8		544	558	539						
to 2:57 AM	477.9	497.8	299.4	401.5	315.2 108.1									
3:00	–	212.9	226.0	253.8										
	626.6	643.4	422.1	540.4	437.4 135.1	730	696	652	74	170				Water Burette = 30.5 @ 3:04
3:04 (?)	Aborted run due to plug (probably @ crucible)													Gas Flow: 100 scc in _____ sec.
														Gas Flow: 100 scc in _____ sec.
	* Final Wts on Triple Beam Balance - Ohaus balance in Iso Cal. check 1 kg Ohaus wt registers ≈999.3 g													Gas Flow: 100 scc in _____ sec.

RUN #8 - Steam Reformation of IGEPON TC-42

Steam Reformation Data Sheet

26.65 Tare
+Al2O3 29.43 ~~28.80~~
+Igepon: 32.21
+Al2O3 33.10
+Igepon: 35.20
+Al2O3 36.77
+Igepon: 39.18
+Al2O3 41.28
+Igepon:
+Al2O3 44.23 (47.70)
+Igepon: 45.19
+Al2O3
+Igepon:

Trial Beaker 28.99
+Al2O3 38.76 7x14 mesh 9 grams
+Igepon 39.70
Rolls up like (dough in oatmeal)
→ 38.96 3/22/96 for 2 hrs @ 130°C

Date: 3-1-96
Page: 1 of ___

Material Tested: GAF IGEPON TC-42
Sample Weight: #81 "from Drum 7/2/90"
Crucible Tare: 26.65 grams
Tare + Al2O3: 38.65
Tare + Al2O3 + Sample: 45.19 (6.54 g)
** Final wt 37.63
(no trace of char; some yellow color - salt)

Set Temperatures:
Set Point #1: 760. (1400°F)
Set Point #2: 760.
Set Point #3: 760.
Ice Bath: 0°C

Trap Weights Gasifier:
Water Gross: 1009.2 g.
Water Tare: * 975.5 g. } 33.7 g
Filter Gross: 0.06
Filter Tare: 0.06 g.
Filter Pore Size: 8 μ

Trap Weights Reformer:
Water Gross: 910.4 g
Water Tare: * 852.7 g } 57.7 g total
Filter Gross: 0.06
Filter Tare: 0.06
Filter Pore Size: 8 μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
									$	Helium: Helium + O2:	130,03 cc/min @ 40 on Rotameter & 91 psia			Gas Flow: 100 scc in _____ sec. avg of 4 " "
3:10	Power ON													
3:10✓ {	-	24.5	22.8	22.8		23	21	23						
	24.3	24.4	24.4	24.3	24.2 24.1				77	78 to amb	40.5✓	6.5-	P5 = 83✓	P4 = 91 P3 = 84 P2 = 92 Burette = 21.5 @ 3:18:08
3:15	-	23.8	23.6	26.7		221	218	216						Gas Flow: 100 scc in _____ sec.
3:17	-	26.7				304	293	293						
3:20✓ {	-	36.5	36.7	49.2		413	392	390						
	228.4	275.5	144.3	180.4	148.7 49.4				77	78 to amb	Pressure Regulator swings up to 94 psi, O2 stopped			
3:24	Water on													Burette = 35.5 @ 3:24:05
3:25	-	106.9	116.9	136.9										
	433.7	469.2	249.5	653.0	275.7 49.0	565	629	518	76	138	37.5✓	14.0✓	89✓	P4 = 97✓ P3 = 99 P2 = 98
3:31						704	671	634						Gas Flow: 100 scc in _____ sec. Burette = 38.0 @ 3:29.04
3:32 {	-	180.4	196.8	262.8										
	661.3	682.7	528.2	572.9	453.4 103.7				77		40.5✓	13.5✓	86✓	P4 = 96 P3 = 86 P2 = 98
3:37✓	Sample of Gasifier (switch to Reformer @ 3:37:30)✓													Burette = 49.0 @ 3:37.07
3:38 {	-	415.1	449.0	465.1										
	739.7	754.3	548.3	703.8	566.9 146.9	755	758	741	77	135	41.✓	14✓	87	@ 3:40:45
3:45-3:49	Bag Sample of Reformer													Gas Flow: 100 scc in _____ sec.
3:46	-	569.7	571.8	580.6										
	745.6	764.6	595.9	739.0	589.0 171.6	767	760	758	77	133	40.5✓	14✓	89✓	P4 = 92 P3 = 84 P2 = 93 Burette = 62.0 @ 3:47:40
3:50✓	Switch to Gasifier													
3:51 {	-	618.1	616.9	618.7										
	746.3	764.4	608.7	746.3	589.0 163.5	760	760	757	77	132	41.0✓	14✓	88✓	P4 = 90 P3 = 81 P2 = 89
3:55:30 to 4:01	Bag Sample of Gasifier													Gas Flow: 100 scc in _____ sec.
3:56	-	649.4	649.4	658.1										
	745.9	766.3	616.4	751.0	588.6 152.2	762	760	755	76.5	135	40.0✓	14✓	93✓	P4 = 95✓ P3 = 88 P2 = 95 Burette = 73.0 @ 3:57:45
4:01✓	switch to Reformer @ 4:01:20													
4:03✓	-	689.1	687.6	687.6										
	745.8	765.6	629.8	754.4	583.7 160.8	757	760	756	75.5	133	40.5✓	14✓	87✓	P4 = 91✓ P3 = 82 P2 = 91 Burette = 81.0 @ 4:04:54✓
4:08	-	701.9	700.4	703.6		757	760	758						Gas Flow: 100 scc in _____ sec.
4:09✓	Sample of Reformer													
4:13 {	-	713.3	710.9	714.2										
	744.6	765.6	692.6	756.6	578.8 167.7	761	759	756	75.	137	40✓	14✓	92✓	P4 = 94✓ P3 = 85 P2 = 95 Burette = 92✓ @ 4:14:30
4:17:20	O2 bottle shut off													
4:25	-	729.1	719.8	725.0										
	743.9	765.4	653.6	752.0	574.1 166.6	758	760	756	76.5	137.	40.5✓	14.	90✓	P4 = 93✓ P3 = 84 P2 = 94 Burette = 106✓ @ 4:26:36

* 3 Bean Ohaus Balance 4:32 End Run T1 - ; 730.5 721.3 734.0 ⇒ Burette = 113 @ 4:32:25✓
** Reactor cover black - lost some Al2O3 on powdering

RUN #9 - Steam Reformation of Wheat Straw

Steam Reformation Data Sheet

Date: 3-4-96
Page: 1 of ___

Material Tested: Straw from AMES (Lampeter)
Sample Weight:
Crucible Tare: 27.26 g.
Tare + Al2O3: 30.92
Tare + Al2O3 + Sample: 34.50 (~0.2" from top of crucible)

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 760 °C
Set Point #3: 760 °C
Ice Bath: 0 °C

Trap Weights Gasifier:
Water Gross: 1004.4 *
Water Tare: 974.8 *
Filter Gross: 0.06 g
Filter Tare: 0.06 g
Filter Pore Size: 8 μ

Trap Weights Reformer:
Water Gross: 907.3 *
Water Tare: 852.6 *
Filter Gross: 0.06 ~~0.09~~ g. {w/ brown spots maybe wet
Filter Tare: 0.05 g
Filter Pore Size: 8 μ

.18 dried
.12
1.06 g dried.

Residual = 0.31 g greycake (stored) no other color - apparently complete OXIDATION

* Weighing on Ohaus Beam Balance

	Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2 Rotameter	O2 Rotameter	Pressure (psig)	Comments
	3:20 ✓	Furnaces on (start from 100 °C)													Gas Flow: 100 scc in ____ sec.
	3:29 ✓	Ice Bath @ 35.8; Water On; Burette @ 4.6													
	3:30	- 141.9 141.3 154.0													
		397.8 433.1 269.8 335.9 250.3 77.1					550	630	522	77	135	40.5 ✓	14.5 ✓	94 ✓	P4 = 100; P2 = 100; Water into Reformer Burette 8.5 @ 3:32:30
*	3:35 ✓	GC sample of Reformer Effluent													
	3:35:30	- 362.4 379.2 351.4													Gas Flow: 100 scc in ____ sec.
		595.7 621.0 411.8 525.2 403.8 146.0					673	669	635	77		40.5 ✓	14.5 ✓	87 ✓	P4 = 98 ✓ P3 = 90 P2 = 100 14 @ 3:37:15
	3:40	- 431.8 428.1 429.1													
		713.3 740.2 518.6 624.1 501.2 163.2					744	751	700	77	137	40. ✓	14.5 ✓	89 ✓	P4 = 98 ✓ P3 = 91 P2 = 99 18.5 @ 3:41:15
*	3:42:30	Bag Sample Reformer Start @ T2 = 500 °C													
	to 3:47:00	Bag Sample Reformer end @ T2 587.6 °C													Gas Flow: 100 scc in ____ sec.
	3:48	- 603.7 600.4 581.3													
		744.3 744.2 610.3 725.8 598.9 190.1					763	759	760	77	137	40. ✓	14. ✓	89 ✓	P4 = 100 ✓ P3 = 93 P2 = 101 28.0 @ 3:49:56 ✓
	356	- 692.3 650.9 647.5					cold trap @ 36.0 °C								
		744.5 769.0 640.1 745.8 596.4 190.9					758	760	755	77	137	40. ✓	14. ✓	87 ✓	P4 = 99 ✓ P3 = 90 P2 = 99 37 @ 3:57:56
							cold trap @ 36.4 °C								Gas Flow: 100 scc in ____ sec.
	4:04	- 723.2 716.6 692.8													
		744.1 768.8 655.8 748.3 589.7 186.5					760	760	760	77	137	38 ✓	14 ✓	85 ✓	P4 = 99 ✓ P3 = 90 P2 = 100 46 ✓ @ 4:06:03
*	4:07 ✓	GC sample of Reformer;					cold trap @ 36.7 ✓								
	4:07:40 ✓	Switch flow to gasifier													
	4:12 ✓	- 734.9 737.4 717.2													
		743.5 769.9 663.9 752.9 588.3 168.2					760	760	760	77	137	40 ✓	14 ✓	90 ✓	P4 = 96 ✓ P3 = 89 P2 = 100 55 ✓ @ 4:13:46
*	4:17:00 to 4:4:21 ✓	Bag Sample of Gasifier Effluent													Gas Flow: 100 scc in ____ sec.
	4:21:30	Switch flow to Reformer													65 @ 4:22:10
	4:24 ✓	- 737.8 722.2 727.6													
		743.5 769.3 677.0 758.7 582.6 174.2					757	760	760	77	137	39 ✓	14 ✓	90 ✓	P4 = 99 ✓ P3 = 90 P2 = 100 69 @ 4:26:42
*	4:29-:34	- Bag sample of Reformer Effluent													
	4:34:30	Switch flow to Gasifier Effluent													Gas Flow: 100 scc in ____ sec. 80 @ 4:35:34 ✓
	4:36 to 4:38 ✓	- 739.6 739.6 735.3					37.2 °C on bath								
		742.7 770.6 686.0 759.9 580.9 168.9					760	760	760	77	137	40.5 ✓	14 ✓	90 ✓	P4 = 94 ✓ P3 = 85 P2 = 96 82.5 @ 4:38:15 ✓
*	4:40 ✓	GC sample of Gasifier													
	4:44	Stop O2 flow													
	4:44:30	- 744.1 744.2 744.3					37.4 °C ice bath								
		743.1 772.1 689.7 757.2 579.3 157.3					760	760	760	77	130	44.	0.	85. ✓	P4 = 36 P3 = 81 P2 = 90 47.5 @ 4:46:42

4:36:42 water off; furnaces off; 5:00 Helium off

RUN #10 IGEPON TC-42
Reformed @ 1600°F

Steam Reformation Data Sheet

Tare = 26.82
+Al2O3 29.25
+Igepon = 30.14
+Al2O3 31.65
+Igepon = 33.23
+Al2O3 35.47
+Igepon 36.62

+Al2O3 39.07
+Igepon = 41.49)2.42
+Al2O3 44.61
+Igepon = 47.23)2.62
+Al2O3 49.48

Al_2O_3 = 14.02 g
14.02
14.02
Igepon = 8.66
8.66

Date: 3-6-96
Page: 1 of 1

Material Tested: IGEPON TC-42
Sample Weight:
Crucible Tare: 26.82
Tare + Al2O3: 40.82
Tare + Al2O3 + Sample: 49.48
Final wt .... 39.89 g ?
(Need to vacuum heat 10 g of reg'd Al_2O_3

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871 °C
Set Point #3: 871 °C
Ice Bath: 0 °C

Gross: 38.96
Tare: 29.06
Net: 9.90 before →

38.48 3/22
29.06
9.42 3/22

1:45pm 40.09
3:35pm 39.67 Vac@150°C
1:35pm 39.66

Trap Weights Gasifier:
Water Gross: 1011.7 *
Water Tare: 975.8 *
Filter Gross: 0.06 g.
Filter Tare: 0.06 g.
Filter Pore Size: 8μ

Trap Weights Reformer:
Water Gross: 917.3 *
Water Tare: 852.8 *
Filter Gross: 0.055 g.
Filter Tare: 0.055 g.
Filter Pore Size: 8μ

<table>
<tr><th>Time (hr:min)</th><th>TC #1 (deg C)</th><th>TC #2 (deg C)</th><th>TC #3 (deg C)</th><th>TC #4 (deg C)</th><th>TC #5 (deg C)</th><th>T1 (deg C)</th><th>T2 (deg C)</th><th>T3 (deg C)</th><th>Water Rota meter</th><th>Water P (psig)</th><th>~~N2~~ He Rotameter</th><th>O2 Rotameter</th><th>Pressure (psig)</th><th>Comments</th></tr>
<tr><td>3:00 - 3:30</td><td colspan="5">Preheat reactor, furnace to 100°C while calibrating flows</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Gas Flow: 100 scc in _____ sec.</td></tr>
<tr><td>3:43 ✓</td><td colspan="5">All furnaces ON</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3:44 ✓</td><td colspan="5">- 50.6 50.7 51.9</td><td>water @ 0°C</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">24.3 24.9 24.9 24.5 24.4 23.4</td><td>156</td><td>88</td><td>74</td><td>78</td><td>54</td><td>39 ✓</td><td>16.5 ✓</td><td>93.5 ✓</td><td>P4 = 108 ✓ P3 = 97.5 P2 = 110 {Barnette = 59cc @ 3:47 ✓</td></tr>
<tr><td>3:48:20</td><td colspan="5">- 53.6 53.7 57.0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3:50 ✓</td><td colspan="5">- 52.7 52.7 62.6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Gas Flow: 100 scc in _____ sec.</td></tr>
<tr><td></td><td colspan="5">136.9 152.8 110.3 107.8 94.6 41.0</td><td>409</td><td>346</td><td>339</td><td>77.5</td><td>55</td><td>40 ✓</td><td>19. ✓</td><td>90. ✓</td><td>P4 = 102 ✓ P3 = 94 P2 = 104 {Barnette = 65.5 @ 3:52:25</td></tr>
<tr><td>3:55</td><td colspan="5">- 95.5 101.5 131.4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>* 3:55:10 ✓</td><td colspan="5">Water flow cut IN</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>{Barnette = 69 @ 3:55:15</td></tr>
<tr><td>4:00 ✓</td><td colspan="5">- 179.9 174.2 184.1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">518.0 536.7 349.1 443.3 344.6 137.2</td><td>680</td><td>617</td><td>586</td><td>75.</td><td>127</td><td>39 ✓</td><td>15.5 ✓</td><td>90 ✓</td><td>P4 = 102 ✓ P3 = 94 P2 = 102 Barnette = 70 ✓ @ 4:01:35</td></tr>
<tr><td>⇒ * 4:02 ✓</td><td colspan="5">GC run of reformer</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Gas Flow: 100 scc in _____ sec.</td></tr>
<tr><td>4:07:29 ✓</td><td colspan="5">- 235.7 260.1 409.2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">732.3 748.7 531.6 635.2 522.4 167.7</td><td>753</td><td>781</td><td>711</td><td>77</td><td>133</td><td>39 ✓</td><td>18. ✓</td><td>94 ✓</td><td>P4 = 106 ✓ P3 = 95 P2 = 104 {Barnette = 85 @ 4:09:14</td></tr>
<tr><td>⇒ 4:10-4:12:4</td><td colspan="5">Bag sample of Reformer Effluent</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4:10:40</td><td colspan="5">- 496.1 486.7 509.4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4:13:22 ✓</td><td colspan="5">Switch flow to gasifier</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Gas Flow: 100 scc in _____ sec.</td></tr>
<tr><td>4:15</td><td colspan="5">- 599.4 590.4 571.9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">855.0 874.7 662.0 775.4 647.8 173.3</td><td>762</td><td>864</td><td>807</td><td>77</td><td>127</td><td>40 ✓</td><td>19. ✓</td><td>86 ✓</td><td>P4 = 100 ✓ P3 = 95 P2 = 104 93.5 ✓ @ 4:16:50</td></tr>
<tr><td>⇒ 4:19-4:23 ✓</td><td colspan="5">Bag sample of Gasifier Effluent ✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4:21</td><td colspan="5">- 611.7 610.6 621.5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">860.6 879.6 706.6 845.7 709.5 206.4</td><td>760</td><td>870</td><td>852</td><td>77</td><td>130</td><td>40.5 ✓</td><td>19. ✓</td><td>92 ✓</td><td>P4 = 104 ✓ P3 = 94 P2 = 103 100 ✓ @ 4:22:15</td></tr>
<tr><td>4:23:30</td><td colspan="5">Switch flow back thru Reformer</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Gas Flow: 100 scc in _____ sec.</td></tr>
<tr><td>4:29</td><td colspan="5">- 669.3 654.3 667.9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">860.1 881.9 750.3 872.9 723.6 231.7</td><td>761</td><td>872</td><td>871</td><td>77</td><td>133</td><td>40. ✓</td><td>18. ✓</td><td>91 ✓</td><td>P4 = 104 ✓ P3 = 95 P2 = 105 104.5 @ 4:30:52</td></tr>
<tr><td>⇒ 4:33:30 ✓</td><td colspan="5">GC run of Reformer</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4:37</td><td colspan="5">- 702.1 699.1 703.5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">859.2 883.7 770.1 881.7 722.4 230.4</td><td>760</td><td>871</td><td>871</td><td>77</td><td>133</td><td>40 ✓</td><td>18 ✓</td><td>91 ✓</td><td>P4 = 104 ✓ P3 = 96 P2 = 104 118 ✓ @ 4:38:45</td></tr>
<tr><td>⇒ 4:40-:45</td><td colspan="5">Bag sample of Reformer Effluent</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Gas Flow: 100 scc in _____ sec.</td></tr>
<tr><td>4:45:30</td><td colspan="5">- 713.2 700.2 705.6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">858.9 885.6 785.1 889.2 720.9 227.0</td><td>760</td><td>871</td><td>866</td><td>77</td><td>135</td><td>41. ✓</td><td>19. ✓</td><td>91 ✓</td><td>P4 = 104 ✓ P3 = 95 P2 = 105 128 ✓ @ 4:47:00</td></tr>
<tr><td>4:48</td><td colspan="13">Shut off O_2 bottle – O_2 will keep going for about 15 min from 2100 psi ⇐ (1300 psi 4:57)</td><td></td></tr>
<tr><td>4:54</td><td colspan="5">- 729.6 726.8 723.4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">858.0 886.8 795.9 891.1 717.8 225.0</td><td>760</td><td>871</td><td>876</td><td>77</td><td>133</td><td>39. ✓</td><td>16.5 ✓</td><td>92 ✓</td><td>P4 = 104 ✓ P3 = 94 P2 = 105 143 ✓ @ 4:55:27</td></tr>
<tr><td>4:59</td><td colspan="5">- Switch flow to gasifier only</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5:05</td><td colspan="5">- 741.8 737.2 733.3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">857.8 888.5 806.5 891.4 729.6 205.5</td><td>759</td><td>871</td><td>873</td><td>77</td><td>133</td><td>39 ✓</td><td>16 ✓</td><td>89.5 ✓</td><td>102 ✓ 90 102 162 ✓ @ 5:07:40</td></tr>
<tr><td>** ⇒ 5:08 ✓</td><td colspan="13">GC run of Gasifier O2 off @ 5:12; Furnaces off @ 5:13</td><td></td></tr>
</table>

RUN #11 IGEPON TC-42
Reformed @ 1600°F with 1 hr reformer preheat

Steam Reformation Data Sheet

Date: March 8, 1996
Page: ___ of ___

Material Tested: Igepon TC-42
Sample Weight:
Crucible Tare: 26.64
Tare + Al2O3: 40.57
Tare + Al2O3 + Sample: 49.02
8.45

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871 °C
Set Point #3: 871 °C
Ice Bath: 0 °C

Tare	26.64		
+Al_2O_3	28.60		
+Igepon:		29.89	1.29
+Al_2O_3	32.81		
+Igepon:		34.97	2.16
+Al_2O_3	38.46		
+Igepon:		40.46	2.00
+Al_2O_3	43.49		
+Igepon:		46.49	3.00
+Al_2O_3	49.02		

Al_2O_3 = 13.93 g
Igepon = 8.45
13.93

Trap Weights Gasifier:
Water Gross: 1026.9 g*
Water Tare: 975.3*
Filter Gross: 0.06 g.
Filter Tare: 0.06 g
Filter Pore Size: 8μ

Trap Weights Reformer:
Water Gross: 904.1 g*
Water Tare: 853.0*
Filter Gross: 0.05 g.
Filter Tare: 0.05 g.
Filter Pore Size: 8μ
{.19 .14}

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2 Rotameter	O2 Rotameter	Pressure (psig)	Comments
2:07	Water Flow in													Gas Flow: 100 scc in _____ sec.
2:07	– 852.4	151.6 893.5	146.1 8:10.2	146.0 8:84.2	 742.7 230.0	752	869	867	65	133	40 ✓	14 ✓	98 ✓	P_4 = 102 ✓ P_3 = 93 P_2 = 104 Burette 37 @ 2:08:4
* ~~2:11~~	~~GC sample flow from gasifier~~ (T_2 = 171.5 C) *flow thru gas flow tube													
2:12	– 853.2	173.6 873.9	172.3 821.3	195.4 889.4	 740.0 226.6	466	871	866	77	130	40 ✓	14 ✓	87 ✓	Gas Flow: 100 scc in _____ sec. P_4 = 102 ✓ P_3 = 93 P_2 = 103 37 @ 2:13:2
① A 2:19-2:23	Bag Sample of Reformer Effluent													
2:17:20	– 853.7	191.8 892.5	196.7 829.4	274.8 890.3	 732.2 241.2	655	871	870	77	133	38	14	90 ✓	P_4 = 105 ✓ P_3 = 95 P_2 = 105 42.5 @ ~~2:18:45~~
2:25	– 865.6	491.9 892.1	494.1 836.4	502.0 899.8	 734.3 243.1	762	871	867	77	135	37.5 ✓	14 ✓	90.5 ✓	Gas Flow: 100 scc in _____ sec. P_4 = 107 ✓ P_3 = 97 P_2 = 112 Burette = 54 @ 2:28:10
② * 2:27 to 2:29:25	Bag Sample of Reformer Effluent													
2:29:45	Switch flow to Gasifier													
③ b1 * 2:33 to 2:38:40	Bag Sample of Gasifier Effluent													
2:40	– 857.6	645.0 892.2	632.4 843.2	636.2 898.7	 734.1 229.2	760	871	873	77	133	39 ✓	14 ✓	89 ✓	Gas Flow: 100 scc in _____ sec. P_4 = 104 ✓ P_3 = 93 P_2 = 104 Burette 64 @ 2:41:15
④ 2:42 ✓	GC sample of Reformer Effluent													
2:45	– 856.7	667.5 891.6	665.7 846.8	670.0 902.3	 730.1 238.0	762	871	867	77	133	38.5 ✓	14 ✓	90 ✓	P_4 = 103 ✓ P_3 = 93 P_2 = 104 76 @ 2:47
2:57	– 856.7	714.9 891.9	712.3 850.0	710.2 907.9	 733.0 237.2	759	871	870	77	147	26* ✓	6* ✓	*	Gas Flow: 100 scc in _____ sec. 90 @ 2:59:3 *System plugged – water off for 1 min
													*70	P_4 = 112 ✓ P_3 = 102 P_2 = 106 @ 3:03:30
3:06:30	Switch over to gasifier – solves plug problem – plug must have been in filter													
3:11:30	– 857.0	731.4 892.9	729.5 852.8	729.6 905.5	 730.4 232.6	759	871	867	77	127	40 ✓	16 ✓	88 ✓	P_4 = 100 ✓ P_3 = 90 P_2 = 102 102 @ 3:11:05
⑤ 3:15	GC SAMPLE OF GASIFIER													
3:20	– 857.0	744.7 892.1	742.4 854.7	741.6 910.3	 733.5 223.7	760	871	869	77	127	40 ✓	16 ✓	88 ✓	Gas Flow: 100 scc in _____ sec. P4 = 100 ✓ P_3 = 89 P_2 = 104 115.5 @ 3:23:00
3:35	FURNACES & H2O OFF													

1 Bag sample appears to be leaking – half of gas lost by 4:15 PM (after 1 hr 45 min)

Polyethylene (chopped) Gross = 113.29
Tare = 106.48
Net ⇒ 6.81 g

RUN #12 POLYETHYLENE {Nalgen Bottle 500cc / cut up into ~3/16" × 3/16" squares}

Steam Reformation Data Sheet

Reformed @ 1600°F w/ 1 hr Reformer preheat

Date: MARCH ~~12~~ 19, 1966
Page: 1 of ___

Material Tested: POLYETHYLENE
Sample Weight:
Crucible Tare: 26.24
Tare + Al2O3: 40.59 by difference
Tare + Al2O3 + Sample: 47.40
6.81

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871 } PREHEAT
Set Point #3: 871 }
Ice Bath: 0

3/22 1:40 PM 39.05 Titration } Vm @ 130°C
3:35 PM 38.77 "
3/23 1:45 PM 38.78 " "
3/25 1:30 PM → 38.79 @ 00

Trap Weights Gasifier:
Water Gross: 996.7 mostly end @ Offmission
Water Tare: 975.3
Filter Gross: 0.06 g
Filter Tare: 0.06 g
Filter Pore Size: 8μ

Trap Weights Reformer:
Water Gross: 888.3
Water Tare: 852.7
Filter Gross: 0.07 g
Filter Tare: 0.06 g
Filter Pore Size: 8μ

853.9 + 34.38
34.4
888.3

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2/He Rotameter	O2 Rotameter	Pressure (psig)	Comments
2:14 ✓	-	30.6	.30.7	31.0										Gas Flow: 100 scc in _____ sec.
	343.6	398.3	215.1	280.2	208.7 67.7	53	476	463	81	86	40 ✓	13 ✓	89 ✓	P2=104 NO P3=93 P4=102 ✓ Burette 4.0
	(bottom heaters on @ 2:00 - Top heater still off.													
2:22	-	54.2	55.2	56.6										
	612.1	644.9	419.7	534.0	420.2 105.1	98	672	625	80	85	40 ✓	13 ✓	88 ✓	103 ✓ NO 91 101 ✓ Burette = 6.5 ✓ 2:23:35
2:24:20	Top Furnace ON													
2:26	-	76.8	78.7	77.9 "										Gas Flow: 100 scc in _____ sec.
	714.6	748.9	517.7	624.3,	509.3 185.1	202	759	690	80	85	40 ✓	13 ✓	88 ✓	P3 = 103; 91 101 ✓ Burette = 11.5 ✓ 2:27:45
⇒ 2:28:10	WATER ON ⇐													
2:29	-	98.4	100.3	107.1										
2:33:30	-	171.1	176.8	172.6										
	844.2	876.7	661.4	751.5	626.6 169.0	523	862	783	77.5	143	40 ✓	9 ✓	91 ✓	105 94 104 ✓ Burette = 21 2:34:05
* — 2:34 ✓	GC sample of Gasifier Effluent													Gas Flow: 100 scc in _____ sec.
2:35 ✓	Switch flow to Reformer													
* — 2:38-2:44	Bag Sample of Reformer Effluent													
2:38:30	-	182.4	182.0	200.7										
	855.0	886.5	714.7	821.9	687.3 213.4	693	872	838	77	147	38.5 ✓	8 ✓	90 ✓	106 96 P4 = 106 ✓ Burette = 26.5 ✓ 2:41:16 >110 104 110 ✓
2:46	-	292.2	328.3	362.1										
	859.0	887.9	747.4	861.2	723.6 236.3	757	871	862	77	157	26. ✓	4 ✓	85 ✓	Gas Flow: 100 scc in _____ sec. Burette = 35 ✓ 2:48:14
2:50 ✓	Problems with plugging (HAD TO DROP BACK PRESSURE TO 55)													
* — 2:55:30 to 2:58 ✓	Bag Sample of Reformer Effluent - BACK PRESSURE STILL @ 55													
3:03:30	-	673.5	675.2	672.2										
	856.1	895.7	785.3	875.7	726.2 230.2	761	872	874	77	130	48 ✓	23 ✓	55 ✓	P2 = 89 77 P4 = 88 ✓ Burette = 55 ✓ 3:05:25
* — 3:06:20 ✓	GC sample of Reformer													
3:07:30	-	690.2	692.5	688.1										Gas Flow: 100 scc in _____ sec.
	857.7	888.3	790.1	884.9	727.3 226.0	762	871	868	78	117	63 ✓	30 ✓	53 ✓	P3 = 76 = 65 P4 = 74 ✓ Burette = 58 ✓ 3:08:50
* — 3:10 to 3:13:30	Bag Sample of Gasifier Effluent													
3:14	-	715.1	716.6	712.3										
	856.9	888.5	795.7	889.7	728.6 213.9	762	871	871	77		43 ✓	17 ✓	53	P3 = 100 = 85 ✓ 97 ✓ Burette = 66 ✓ 3:15:35
3:16	FURNACES OFF													Gas Flow: 100 scc in _____ sec.
3:20	WATER OFF (Burette @ 71.0 even)													

RUN #13 - Sugar (Sucrose) @ 1400 °F
with Steam Only

Steam Reformation Data Sheet

+ Sugar 1 packet Marriott 45.36
2 packets " 48.17
~40% 3rd " 49.18 grams
less Tare + Al_2O_3 42.58
6.60 grams

7..

28.04 - fine Al_2O_3 0.93 g ← in Gooch after 24 hr vac @ 140°C
42.58 - 7-14 mesh Al_2O_3 14.54 g ← in beaker " " "

Date: 3/25/96
Page: 1 of __

Material Tested: Sucrose
Sample Weight:
Crucible Tare: 27.11 + 1.0 g fines
Tare + Al2O3: 41.54 14.42 in beaker
Tare + Al2O3 + Sample: 48.16

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: ~~871~~ 760°
Set Point #3: ~~871~~ 760°
Ice Bath: 0

Beaker Gross 43.50 ← in beaker on 3/22
<14.42> Al_2O_3
29.08 beaker

Trap Weights: Gasifier:
Water Gross: 1001.7
Water Tare: 976.3
Filter Gross: 0.06 g (turns & light tan)
Filter Tare: 0.06 g
Filter Por Size: 8 μ

Trap Weights Reformer:
Water Gross: 856.7
Water Tare: 853.3 g
Filter Gross: 0.06 white
Filter Tare: 0.06 g
Filter Pore Size: 8 μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
1:25 1:35 1:50	Turn on furnace #2 & #3 Note that 2nd furnace apparently inoperative - 50.7 52.2 50.5 251.8 235.0 379.6 677.8 567.4 143.1					72	177	728	80	55	38.5	0	P_1 92	P_2 = 89 P_3 = 97 P_4 = 0 Burette = 40 @ 1:53
1:54 2:00 2:02 2:06	Turn on furnace #1 - 97.1 100.8 108.7 296.6 268.9 451.3 737.7 615.6 156.0 Water flow on Bag Sample of Gasifier Effluent					344 (T_2 = 155.7° @ 2:06;	214	763	77.5 = 175.8° @ 2:12:30)	55	38.5		93	89 98 Burette = 50 @ 2:01:50
2:16 2:19:20 2:27:30	- 191.8 198.5 255.9 333.9 317.2 475.6 750.2 604.6 149.8 Bag Sample of Gasifier Effluent - 501.6 519.2 550.2 356.7 344.4 495.3 754.1 594.7 150.1					747 (T_2 = 277.7 @ 2:20:10; 765	275 302	755 756	77 = T_2 = 444.4 @ 2:27 PM) 77	147 155	10. * 0 *		90 81	P_2 = 120 * P_3 = 116 Burette = 68 @ 2:17:40 P_2 = 122 * 126 Burette = 82 @ 2:24:25
2:35:45 2:38 2:52	- 637.4 640.9 645.9 362.2 358.6 501.9 753.2 593.9 147.3 Bag Sample of Gasifier Effluent - 705.1 706.4 705.7 380.6 385.9 517.4 756.7 591.6 145.3					758 (2:38:45 T_2 = 659.9; 756	319 346	765 755	77.5 T_2 = 703.8 @ 2:50 PM) 77.	- 150	0 0		84 87	P_2 = 123 123 Burette = 71 @ 2:37:37 P_2 = 120 116 Burette 109 @ 2:53:33
2:54 2:54:30	Water off Furnaces off													

Notes: ① All tares w/ calibrated Ohaus #2204-5012 back in service
② Yellowing of Al_2O_3 after 24 hrs vac @ 140°C
1.00 g fines → 0.93 g after vac heat } ~7% wt loss
14.42 g Total → 13.50 g "

RUN #14 - Cellulose @1400°F
wi Steam only

523.7 g Ruthenium Catalyst - 630 cc Vol

Steam Reformation Data Sheet

Date: Tues 3-26-96
Page: 1 of ___

Material Tested: AVICEL PH-200
Sample Weight:
Crucible Tare: 27.39 g
Tare + Al2O3: 31.26 g
Tare + Al2O3 + Sample: 37.82 6.56 → Dried to 37.34 g prior to run in Vac Oven
in beaker, not crucible → to 33.86 3/27/96 to 33.50 5/3/96

Set Temperatures:
Set Point #1: 760
Set Point #2: ~~960~~ -
Set Point #3: ~~900~~ 871 °C
Ice Bath: 0

Trap Weights: Gasifier:
Water Gross: ____
Water Tare: 976.25
Filter Gross: 0.05 g (after vac oven)
Filter Tare: 0.06 g
Pore Size 8μ

Trap Weights Reformer:
Water Gross ____
Water Tare 853.3
Filter Gross 0.06 g
Filter Tare 0.06 g
Pore size 8μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ /He Rotameter	O2 Rotameter	Pressure (psig)	Comments
	center heater still out → set bottom heater to 871°C												← New Pressure Gages 0-160 psig →	
3:15	Helium Flow 137 cc/min @40.5; Water Flow = 1.19 cc/min											0°C on both	96	
3:15	Bottom Furnace On SP = 871													
3:20	-	27.4	27.3	27.2										
	50.2	44.0	51.8	97.2	78.7	36.4	28	49	273	80	60	40✓	-	98✓	P2 = 105; P3 = 110; P4; Burette = 5@3:22:
3:28	-	30.1	30.2	30.2										
3:29:30	124.3	131.7	141.8	431.4	347.8	90.5	37	77	551	86	57	41.5✓	-	95✓	P2 = 103; P3 = 110✓ Burette = 15.5@3:32:[illegible]
3:38	-	43.5	43.8	44.0										
	225.2	164.7	249.7	655.0	548.4	165.9	57	111	705	80	57	45✓		90✓	P2 = 99 P3 = 97✓ 25@3:39:45
3:45	-	63.0	63.8	62.8										
	292.7	193.6	367.7	785.6	672.1	187.1	77	145	805	80	60	45		92✓	P2 = 98 97✓ 32@3:46:
* 3:54:1	Turn Water Flow into Gasifier; TURN Top Furnace ON													
3:54	-	110.5	112.6	111.7										
	332.1	265.5	443.3	871.0	746.3	214.1	110	180	869	73.5	133	45✓		92✓	P2 = 99 P3 = 98✓ Burette 44@3:56:15
~~4:00~~	Bag Sample ~~of Gasifier Effluent~~													
4:01:33	-	160.2	159.5	152.3										
	333.8	291.5	467.1	878.9	745.8	213.6	131	195	866	74	143	35.5✓		85✓	P2 = 110 P3 = 109✓ Burette 55@4:05:05
4:02:30 to 4:17	Bag Not on - Bag Sample of Gasifier Effluent													
4:05:30	2nd Furnace switched on - working ??													
4:13	-	175.5	176.1	175.2										
	495.2	513.2	548.6	880.2	737.1	200.2	190	406	875	74	153	22✓	-	85✓	P2 = 117 115✓ Burette 65@4:15:00
4:18-4:29	Bag Sample of Gasifier Effluent													
4:30-4:42	Bag sample of Gasifier Effluent													
4:32	-	176.1	176.0	244.7										
	522.6	539.9	568.5	882.7	730.0	195.3	266	394	875	74	153	23✓	-	87✓	P2 = 115 P3 = 114✓ Burette 87@4:35:20
4:41	-	221.0	256.7	296.9										
	516.6	534.9	574.0	886.3	730.9	197.2	292	389	869	74		23✓		90✓	P2 = 115 P3 = 114✓ Burette 97@4:43:00
4:43:00	Water Off													
4:44	Furnaces Off													
4:44:15	-	279.4	284.9	307.4										
4:47	-	295.4	302.6	318.9										
4:50	-	390.2	381.0	354.0										
4:53	-	358.1	355.5	348.6										
4:57	-	354.7	354.4	352.3										

RUN #15 - Cellulose Char @ 1400°F

Steam Reformation Data Sheet

Date: Thur 3-28-96
Page: 1 of ___

Material Tested: Cellulose Char
Sample Weight:
Crucible Tare: ________ } see run #14
Tare + Al2O3: ________ }
Tare + Al2O3 + Sample: 33.86
After run Gross wt ⇒ 32.01g

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871 °C
Set Point #3: 871
Ice Bath: 0

Trap Weights; Gasifier:
Water Gross: ~~1050.0~~ 1021.6 g
Water Tare: 976.2
Filter Gross: 0.065 lt. tan
Filter Tare: 0.06 g
Pore Size: 8 μ

Trap Weights, Reformer
Water Gross: 933.7
Water Tare: 853.2
Filter Gross: 0.055
Filter Tare: 0.06 g
Pore Size: 8 μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
9:38	Turn on bottom furnaces* (preheat) - Start 3 pen recorder *(2nd from bottom @ 37:40)													
9:39	- 23.8	27 23.8	27 231	26 23.3	23.5 27.9	25	23	55			39	-	95✓	P_2 = 99 P_3 = 99✓ Burette = 62✓@ 9:41:40✓
9:54	- 479.3	44 516.6	48 254.2	53 488.7	392.3 95.2	74	568	586	77	44	39✓	-	90.5	P_2 = 95.5 95.5✓ 79✓@ 9:56:35✓
10:00✓	Top Furnace On: Water in													Burette = 83.5✓@ 10:00:25
10:01:30	- 690.4	82 717.9	86 424.7	73 659.8	563.4 131.8	178	731	712	76	130	40✓	-	94✓	P_2 = 97 P_3 = 94 13.1 ? ✓ Burette = 86.5@ 10:03:00
10:06	- 753.7	153 774.9	156 516.4	164 752.0	654.5 158.6	413	758	790	78	140	32✓	-	86.5	P_2 108 107✓ Burette = 93✓@ 10:09:45✓
10:10	-	172	176	198										
* 10:13 to 10:18✓	Bag Sample of Gasifier													
10:14:45	- 759.2	198 772.9	222 590.7	266 852.0	747.7 207.6	670	761	864	77	147	18:21✓	-	82✓	P_2 = 112 P_3 = 116✓ Burette = 102✓@ 10:16:40
10:16	Change SP of middle furnace from 760°C to 871°C													
* 10:18:30✓	Bag Sample of Gasifier (to 10:28)													
10:20 to 10:24	- 833.8	426 848.9	429 644.3	450 871.8	760.1 218.2	755	855	870	77		15✓	-	89✓	P_2 = 115 P_3 = 121✓ Burette = 108✓@ 10:21:40
10:27✓	- 868.8	575 881.8	578 687.2	589 878.3	757.3 216.2	757	872	868	77		8	-	85✓	P_2 = 122 P_3 = 123✓ Burette = 117.5@ 10:35:00
* 10:28:30✓	Bag Sample of Gasifier to 11:08					(10:48:15)								
10:35✓	Large ΔP problem – Drop Back Pressure to 70 psig													
10:38:30	- 869.2	678 880.8	681 704.1	685 880.0	748.1 210.1	761	871	871	77	160	<0✓	-	65✓	P_2 = 121 P_3 = 120✓ Burette = 128.4@ 10:39:40
10:46	Increase Bottle Pressure to 130 psig													
10:50	- 869.1	He 719 881.8	722 717.3	726 893.1	745.4 207.8	761	871	872	77	167	<0 *✓		64✓	P_2 = 133 P_3 = 136✓ Burette = 143✓@ 10:52:10✓
11:00	- 868.2	734 880.7	739 727.7	743 890.5	748.2 206.6	759	872	870	77	165	<0 *✓	-	58.5	P_2 = 129 P_3 = 130✓ Burette = 156✓@ 11:03:15
* 11:08✓	Bag sample of Reformer Effluent to 11:15:50													
11:12	- 867.0	689 881.3	691 738.3	699 891.4	748.7 229.7	758	869	867	80	128	41✓		87✓	88 92✓ Burette = 167✓@ 11:14:45✓
* 11:17 to 11:23	Bag sample of Reformer Effluent													
11:20	- 866.6	740 879.5	746 743.6	720 893.6	746.5 222.4	761	872	869	80	135	39.5✓		94✓	P_2 = 97 P_3 = 98✓ Burette = 176✓@ 11:21:25✓
* 11:29	- 868.7	746 881.9	754 749.8	727 895.2	745.1 222.0	759	872	876	-	100	40✓		94✓	97 99✓

6th Bag Sample (Reformer @ 11:25 - 11:30)
Water off @ 11:31 — Burette = 187.8
11:33 All Furnaces Off

RUN #16 - Butyric Acid

will do 2 runs: w/ & w/o Oxygen
Reformer 1st @ 1600°F (3 bags) w/o Oxygen
~~[illegible]~~

± one or more
bags w/ Oxygen

H2COOH bp = 160°C, will distill,
→ must get data fast.

Steam Reformation Data Sheet

26.85 Tare
Gooch Kettle 37.12 w/ 8-14 mesh out w/ can

Date: 3/31/96
Page: 1 of 1

Material Tested: Butyric Acid
Sample Weight:
Crucible Tare: 26.85
Tare + Al2O3: see 8/24 [37.12]
Tare + Al2O3 + Sample: ~~50.40~~ 42.49
After Run 36.86 (no organic residue in evidence)

Set Temperatures:
Set Point #1: 760°C
Set Point #2: 871°C
Set Point #3: 871°C
Ice Bath: 0°C

Trap Weights: Gasifier
Water Gross: 976.5
Water Tare: 976.2
Filter Gross: .06 g
Filter Tare: .055
Pore Size: 8μ

no sample at gasifier

Trap Weights Reformer
Water Gross 917.0
Water Tare 853.2
Filter Gross .06
Filter Tare .06
Pore Size: 8μ

Separate prep 50 ml crucible
Tare 31.68
Al2O3 25-30 mesh 37.28
+ Butyric Acid 47.46 -.02
Al2O3 7-Mesh ... 52.45 -.02
Al2O3 ... 54.25
54.17

31.81 residual
same C3H7COOH
loaded thru site

⇒ (10.18 - .02)(37.22 / 37.42) = 10.06 g. Butyric
g Al2O3

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments
12:50	Turn on lower furnaces ② & ③													
12:55	- 89.3	19 91.7	19 67.1	23 93.7	80.6 35.4	27	265	269	77.5	46	40.5	-	97	P2 = 95 P3 = 100 P4 = 103
1:02	- 379.9	24 407.8	26 212.7	31 386.2	293.1 76.8	52	516	513	77.5	47	42.5	-	92	P2 = 95 P3 = 96 P4 = 98
1:08	- 627.1	38 641.6	40 375.0	47 587.9	531.9 139.5	87	681	662						
1:13	O2 off (on for calibration)													
1:14	- 796.2	74 804.0	79 523.7	93 761.9	671.2 180.1	138	820	778	78	48	41	-	94	P2 = 98 P3 = 99 P4 = 37 Burette 9.5 @ 1:17
* 1:18-1:21	Bag Sample of Reformer Effluent													
1:19	- 867.6	142 872.4	141 616.6	137 858.6	756.6 228.5	182	872	859						
1:23:46	Water flow in													
1:29	- 871.1	164 876.9	167 681.1	174 894.5	777.9 256.1	250	868	872	77	135	40	-	95	100 103 22
1:32	Oxygen flow on													
1:33	- 867.7	172 872.6	175 690.1	188 893.7	768.5 270.7	271	874	867	77	135	41	3.5	94	102 101 105 Burette = 30.5 @ 1:35:20
* 1:37:15 to 13:39:30	Bag Sample @ 13:37 (Reformer)													
13:39	- 869.3	195 875.3	204 701.9	222 896.8	765.2 272.1	306	869	874	77	137	41	2.0	98	100 102 102 Burette = 39.0 @ 1:42:55
* 13:44:30 to 13:48:10	Bag Sample of Reformer													
13:45:55	Turn on Top Furnace ①													
13:49	- 868.6	254 875.7	259 712.9	281 905.0	766.3 268.0	473	870	866	77.5	137	40	1.0	96	P2 = 101 103 105 Burette = 49.0 @ 1:51:15
* 13:53	Bag Sample of Reformer w/ O2 (to 13:58)													
13:55	- 868.4	319 873.5	331 718.2	357 902.3	762.0 266.1	678	873	875	78	137	40	0.5	94	98 98 101 56.0 @ 1:57:00
* 2:00-	Bag Sample of Reformer w/ O2													
2:03	- 871.8	459 873.7	468 726.0	498 906.3	762.0 265.7	760	872	867	78	138	40	1.5	94	101 103 105 Burette 63.0 @ 2:03:15
2:06	- 871.6	555 873.6	568 730.2	578 907.4	761.7 265.2	759	873	867	78	135	41	2.0	92	101 100 104 Burette 68.5 @ 2:08:20
* 2:07 - 2:13	Bag Sample of Reformer w/ O2													
2:14	- 874.8	648 876.6	654 737.4	652 909.6	760.3 263.8	761	870	873	78	135	42	2.0	94	100 99 100 79.8 @ 2:18:00

Bag Sample w/o O2 @ 13:28

→ will water/furnaces off

All dish G w/ paper 3.98
dish R w/ beaker 2.7
<3.3
= 0.41

dish R w/ paper 3.29

dish G w/ wet 5.40
<3.98>
= 1.42

spillage - will have to get acid C3H7COOH wt by difference from 42.49 g gross wt.

RUN #17 - METHIONINE

2.4
7.2
10.4

Tare 27.27
$+Al_2O_3$ 32.86
5.59
+ 6.81
Al_2O_3 + Gooch 12.40
27.27
39.67 → 39.67
44.43 gross
4.76

Tare 29.49
+ Meth 34.26
$+Al_2O_3$ 41.07
29.49

4.77 Methionine check

Steam Reformation Data Sheet

Date: 4-1-96
Page: ___ of ___

Material Tested: D-L METHIONINE
Sample Weight: 99%. Acros #72435/1 (lot)
Crucible Tare: 27.27
Tare + Al2O3: 39.67
Tare + Al2O3 + Sample: 44.43
4.76 g net
After Run 38.11 g wt

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871 °C
Set Point #3: 871 °C
Ice Bath: 0 °C

Trap Weights: GASIFIER
Water Gross: 976.5
Water Tare: 976.3
Filter Gross: 0.06
Filter Tare: 0.06
Pore Size: 8 µ

.17
.17
.19
.17

Trap Weights; REFORMER
Water Gross: 918.8
Water Tare: 853.2
Filter Gross: 0.06 g
Filter Tare: 0.06
Pore Size: 8µ

.19
.17

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2/He Rotameter	O2 Rotameter	Pressure (psig)	Comments
1:40	Turn on Furnaces ② & ③													
1:54	- 483.9	38 501.4	42 270.8	46 468.8	379.8 100.6	72	576	561	77	57	43	-	93.5	P_2 = 97 P_3 = 98 P_4 = 20 Burette = 41 @ 1:57:25
2:01	- 690.7	60 691.3	64 409.9	67 641.3	537.6 137.4	113	721	683	78	58	43	-	93.0	97 97 20
* 2:04	Bag Sample of Reformer Effluent (w/o steam)													
2:05 to 2:07	- 794.7	84 802.6	88 500.0	89 741.1	627.5 168.6	152	833	773	78	57	43	-	92	97 97 18
2:09	Water Flow in @ 2:09				Burette = 55 @ 2:09:35									
2:11	- 871.1	124 880.5	130 609.5	121 841.2	717.4 178.2				78	140	40	-	92	97 97 16 Burette = 58.5 @ 2:12:30
* 2:15- to 2:18	Bag Sample of Reformer Effluent (w/ steam)													
2:20	- 868.2	188 878.1	193 676.9	195 889.6	756.7 255.8	249	868	866	78	136	43	-	90.5	96 97 16
* 2:22:40	G.C. analysis of reformer effluent w/o O_2													
2:25	Turn on Oxygen; Furnace ①													
2:26	- 866.2	198 877.1	208 695.4	208 892.7	754.6 257.3	389	869	870	78	137	42.5		91.5	101 99 100
* 2:30-:33	Bag Sample of Reformer Effluent w/ O_2													
2:32	- 869.4	227 879.7	241 708.0	264 900.9	756.5 259.2	530	873	872	78	142	41		95	100 103 104 Burette = 83 @ 14:34:15
* 2:36:30 to 2:39	Bag Sample of Reformer Effluent													
2:37:30	- 868.7	255 877.1	284 717.8	407 901.1	752.1 261.3	710 →736	869 →872	873 →866					92 98	102 100 104 Burette = 91.5 @ 14:41:30
2:42	- 872.7	507 880.2	512 724.9	542 900.4	748.7 260.9	760	869	871	78	140	40		94	102 101 101 Burette = 95 @ 14:44:30
2:48	- 870.6	641 877.9	646 730.4	617 902.4	748.5 255.7	762	873	876	77	138	40	<0 (Ar on)	93	101 101 102 Burette = 103 @ 14:50:30
2:54	- 873.5	658 879.8	664 737.7	661 907.5	750.7 253.8	763	873	870	78	138	40	2.5	92	97 ~~97~~ 104? 102 Burette = 109 @ 14:56:40
* 2:58	G.C. Analysis of Reformer Effluent with O_2													
3:00	- 871.4	(687) 881.7	696 743.2	691 907.4	749.1 252.1	759	870	875	78	138	40	2.0	94	100 102 103 ~~Burette~~
3:05	O_2 & Furnaces off (3:06 Furnaces off)													
3:08	Water off													Final Burette = 122 @ 15:08:00

Al2O3 in Al dish 15.05

RUN #18 - POLYETHYLENE
wi O2 & Cat Reformer @ 1600 °F

wi Ruthenium
1st Run w. Catalyst
changed to Fulwiles catalyst
for Runs #19 24

Steam Reformation Data Sheet

Date: 4-4-96
Page: 1 of 1

Material Tested: ________
Sample Weight:
Crucible Tare: 26.23
Tare + Al2O3: 39.29
Tare + Al2O3 + Sample: 45.43
13.06 Al2O3
6.14 g Poly
Wt after Run 37.59 g (4-8-96) PG on crucible

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871 °C
Set Point #3: 871 °C
Ice Bath: 0 °C

Trap Weights: Gasifier
Water Gross: 997.2 g
Water Tare: 976.2 g
Filter Gross: 0.06
Filter Tare: 0.06 g
Pore Size: 8μ

Trap Weights Reformer:
Water Gross 865.4 g
Water Tare 853.3 g
Filter Gross 0.065
Filter Tare 0.065 g
Pore Size: 8μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2/He Rotameter	O2 Rotameter	Pressure (psig)	Comments
11:07	Furnaces #2 & #3 turned on!					Water Burette =			63.0 @ 11:08:25					
11:15	-	21	22	23										
	163.7	176.4	76.0	186.6	148.2	28.0 33	366	374	80.5	51	40 ✓	-	93 ✓	P2 = 97 P3 = 97 ✓ P4 = 74 Burette = 77.5 ✓ @ 11:17:25 ✓
11:21	-	28	26	31										
	417.4	412.2	143.7	452.8	394.8	40.4 50	553	565	80.5	51	40 ✓	-	92 ✓	P2 = 99 98 ✓ 50 82.0 ✓ 11:23:50
11:27	-	42	45	46										
	619.3	605.9	268.7	656.4	607.6	105.2 75	699	701	80.5	51	40	-	92	98 98 40
11:34 ✓	-	69	74	79										
	797.7	784.1	400.6	844.1	797.0	143.1 118	852	849	75.0	160	15 ✓	-	85 ✓	125 122 30 Have to drop set pressure to ≈ 70 psig
11:35 ✓	Water Flow on													
11:~~44~~41:30	-	111	114	114										
	838.9	824.4	525.2	893.0	841.6	159.8	160	872	871	66	155	5 ✓	-	67 ✓	134 135 ✓ 23 * Have to back off on water flow (from 0.1" to 0.08" stroke) Burette = 105 @ 11:46:05
11:45 ✓	Oxygen Flow On (avail pressure may still be too low)													* 11:50 water stroke to 0.075" ✓
* 11:54 ~~11:50~~ ✓	GC sample of Effluent Gas (from Reformer)													
11:51	-	177	191	194										
11:59:30	834.9	823.3	573.9	897.6	833.8	160.6	207	872	871	56	158	<0 ✓	<0 ✓	72 ✓	145 145 ✓ 140 Burette = 111.5 @ 11:~~56~~:50
** 12:00-12:42	Bag Sample of Reformer Effluent													
12:01	-	187	200	201										
	835.4	823.2	602.9	901.4	827.5	156.7	256	871	871	55	157	<0 ✓	<0 ✓	72 ✓	142 143 ✓ 141 = 116.5 @ 12:05:20
12:11:30	Turn on Furnace #1													
12:12	-	208	233	231										
	836.5	823.7	627.5	904.7	822.5	~~241.8~~	349	871	871	55	163	<0 ✓	<0 ✓	68 ✓	148 150 ✓ 141 ⟸ complete plug water coming out into the rotameter — 12:16 PM — Turn off water @ 12:17:15 ✓
12:20	-	272	288	294										
	840.5	825.0	640.6	907.4	819.7	152.5	660	871	871						145 146 142 Burette = 128 @ 12:22:30
12:32 ✓	— still no helium flow & relief valve @ P2 venting green liquid													
12:35	-	521	550	584										
	848.7	827.1	662.1	910.2	815.2	150.3	760	871	871			<0	<0	68 ✓	143 144 ✓ 138
** 12:54 ✓	2nd Bag sample of Reformer Effluent — Continue heating w/o water until partial clearing													142 143 40 Burette = 123
12:55	-	721	723	720										
	852.6	830.9	684.2	914.4	812.2	140.5	760	871	871						
1:05 ✓	Switch flow to Gasifier only — mostly filled 2nd Bag @ 12:54													
1:09	P2 & P3 still up there 142 psi — so problem in Gasifier clog & not reformer — That's good news (so gas unloaded into 12:54 bag sample from Reformer reverse flow)													
1:22 ✓	Gasifier Effluent flow 10 cc in					1:51:00 ; 5.41 cc/min	2:06:07 ; 4.74 &	2:16.9 4.38 cc/min			P3 - P5 = (140 - 67) ⟹ 73 psi			
1:35 ✓	-	754	756	756										
	856.0	837.0	708.8	919.2	808.6	135.4	761	871	870			<0 ✓	<0 ✓	68 ✓	138 140 ✓ 15
1:42 ✓	Water back into Gasifier w/ 0.05" stroke (Burette = 137 @ 1:42:45)													
1:45 ✓	Water flow off													
2:16	Gasifier still plugged - shut off power, flows													
2:15	-													

RUN #19 – High Density Polyethylene

Steam Reformation Data Sheet

Date: April ~~16~~ 15, 1996
Page: ___ of ___

Material Tested: HDPE
Sample Weight:
Crucible Tare: 26.82
Tare + Al2O3: 43.05
Tare + Al2O3 + Sample: 49.57
16.23 g Al_2O_3
6.52 g HDPE
snow white Al_2O_3 6.32
spillage ? ⟷ 41.40 g recovery after run
no organics or carbon

check
32.19
26.83
5.32
49.58 gross
⟨10.87⟩
⟨6.52⟩
32.14

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871
Set Point #3: 871
Ice Bath: 0

Trap Weights: Gasifier
Water Gross: 1029.7
Water Tare: 976.0 *
Filter Gross: 0.06 g
Filter Tare: 0.06
Pore Size: 8 μ

Trap Weights Reformer:
Water Gross 937.5
Water Tare 853.0 *
Filter Gross 0.07 g
Filter Tare 0.065 g
Pore Size 8 μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2/He Rotameter	O2 Rotameter	Pressure (psig)	Comments			
														P_2	P_3	P_4	Burrette
1:30	Turn on Furnaces ② & ③: set points 871 °C												P_5 = 99	104	103	105	7.5@ 1:29:00
	Value: Reformer; Chart on @ 1:30 5 cm/hr																
1:40	-	23	24	27													
	240.8	200.8	124.6	184.2	133.7 206	46	426	411	80	51	37 ✓	13 ✓	99 ✓	104	103 ✓	105	25.5@ 1:43:00
1:50	-	43	44	49													
	572.5	532.2	331.3	490.8	395.9 166.2	94	655	608	80.5	51.5	40 ✓	13.5 ✓	94.5 ✓	101	100	102	~~31.5~~@ 1:52:30
1:57	-	74	76	80													
	750.3	715.8	506.8	651.4	549.8 185.4	138	793	706	80.5	52	37 ✓	11.5 ✓	99 ✓	105	104 ✓	107	43 ✓@ 2:00:00
2:02	-	102	103	108		⇐ Cut Water Flow In @ 2:02											45.5@ 2:02:00
2:04 ✓	Furnace ① Turned on																
* 2:07 ✓	GC sample of Reformer Effluent																
2:07:30	-	170	172	176													
	862.5	845.2	697.8	815.3	710.3 227.6	379	872	823	77.5	133	40 ✓	13.5 ✓	94 ✓	100	100 ✓	102	54 ✓@ 2:10:00
* 2:13:30 to 2:18	Bag Sample of Reformer Effluent																
2:14	-	181	183	210													
	861.5	853.9	759.6	874.4	767.4 310.2	615	871	862	77.5	137	37 ✓	12 ✓	98 ✓	105	103	107	61.5@ 2:16:30
2:20	✓	282	292	353													
* 2:20:45 to 2:21:30	Bag Sample of Gasifier Effluent:																
2:23	-	354	376	421													
	859.8	863.4	803.3	906.6	779.8 261.1	759	871	870	77	142	30 ✓	7 ✓	100 ✓	110	109 ✓	111	74 ✓@ 2:27:30
2:25 ✓	Switch flow back to Reformer Side																
* 2:31 to 2:32:30	Bag Sample of Reformer																
2:33 ✓	-	631	634	643													
	855.2	870.2	821.7	913.7	783.7 ~~229.8~~	758	872	870	77	140	30 ✓	6 ✓	97 ✓	111	108 ✓	110	83 ✓@ 2:35:15
* 2:43 ✓	GC Sample of Reformer Effluent																
2:41	-	688	692	689													
	856.9	872.1	832.3	918.5	777.2 254.2	762	870	867	77	140	33 ✓	5 ✓	99 ✓	110	107	109	93 ✓@ 2:44:00
* 2:47 to 2:53	Bag Sample of Gasifier Effluent																
2:50	-	718	721	723													
	856.7	873.8	839.1	925.6	778.1 253.4	759	872	868	77	134	37 ✓	12 ✓	97 ✓	102	101 ✓	104	103@ 2:52:50
2:54 ✓	Switch back to Reformer																
3:00 ✓	Switch back to Gasifier then GC																
3:09	-	742	744	741													
	855.7	876.9	848.6	929.3	776.6 249.2	759	870	869	77	133	38 ✓	12 ✓	94 ✓	102	99	102	124 ✓@ 3:11:15
* 3:22	GC Sample of Gasifier Effluent																

3:23 – O_2 flow shut off; 3:25 Water Flow off; Burette 140 @ 3:25
3:31 – 753 756 751
3:31:30 Furnaces Off

* Successive rinsing in methanol followed by water & air-dry in vacuum oven

Gasifier filter assy = 442.4 g
Reformer " " = 445.1 g

RUN #20 - METHIONINE
wi CATALYTIC REFORMATION @ 1600°F

Steam Reformation Data Sheet

Date: 4-17-96
Page: 1 of 1

Material Tested: ____________
Sample Weight:
Crucible Tare: 27.27 g
Tare + Al2O3: 30.76
Tare + Al2O3 + Sample: 36.86
Tare + Al2O3 after run ⇒ 30.51 g (30.48 5-3-96)

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871
Set Point #3: 871
Ice Bath: 0

Trap Weights: GASIFIER:
Water Gross: 1002.6 g
Water Tare: 976.1 g
Filter Gross: ____
Filter Tare: 0.06
Filter Pore 8μ

TRAP WEIGHTS REFORMER:
Water Gross 905.3 g
Water Tare 853.0 g
Filter Gross 0.06
Filter Tare 0.06
Filter Pore 8μ

Reformer pH ≈
(Nitric Acid sm

Gasifier pH ≈
(strong manure

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ He Rotameter	O2 Rotameter	Pressure (psig)	Comments P2	P3	P4	Burette
2:30:05	FURNACES ② & ③ ON																
2:42	-	29	28														
	304.8	278.5	185.8	264.7	196.6	64.7	59	472	410	78	53	40	-0-	99 ✓	104	103	37	10.5 @ 2:44:30
2:51 ✓	O₂ on → Switch flow to GASIFIER																
2:52:30	-	79	82	101													
	633.4	607.4	420.0	566.6	474.6	134.7	122	709	649	78	53	40	15	98.5 ✓	103	103 ✓	105	27.5 @ 2:55:00
2:57 ✓	Switch Furnace ① ON																
2:57 ✓	Switch Water Flow ON					← Burette = 30.5											
2:58:30	-	115	116	120													
	769.8	750.7	539.3	689.4	592.3	156.2	252	822	729	77	138	40 ✓	14.5 ✓	99 ✓	103	102 ✓	104	35 @ 3:01:00
3:04	-	162	162	177													
3:05	-	163	168	186													
	852.1	835.3	632.8	783.7	682.6	198.5	517	866	797	77	138	40 ✓	15 ✓	97 ✓	104	102 ✓	105	42 @ 3:09:15
* 3:10 ✓	GC sample of GASIFIER																
* 3:14 - 3:16	Bag Sample of Reformer																
3:15	-	287	267	383													
	856.7	844.4	720.9	872.9	772.8	254.5	764	870	867	77	138	40 ✓	15 ✓	98 ✓	104	104 ✓	108	55 @ 3:18:45
* ✓ 3:14-3:17	Bag Sample of Gasifier																
3:27	-	647	647	644													
	857.7	857.2	765.4	901.2	785.1	266.8	762	869	867								
* ✓ 3:25-3:29	Bag Sample of Reformer																
* ✓ 3:34-3:40	Bag Sample of Gasifier																
3:35	-	691	693	693													
	855.3	857.6	778.0	903.1	778.2	260.6	760	871	869	77	137	40	15 ✓	101 ✓	106	104 ✓	106	76 @ 3:37:30
* 3:46 ✓	GC Sample of Reformer																
3:44	-	716	717	719													
	856.6	862.3	791.1	907.8	780.3	257.0	759	870	866	77	139	38 ✓	14 ✓	100 ✓	107	105 ✓	107	87 @ 3:47:00
3:53	-	729	729	733													
	852.0	864.6	800.5	911.2	783.6	262.0	760	870	872		139	37 ✓	14.5 ✓	101	107	106 ✓	108	96 @ 3:55:00
4:00	O₂ off																
4:02 ✓	Water off																
4:02	-	736	739	742			761	869	869								
	849.9	864.7	810.3	912.3	781.7	256.6				-0-	14	38 ✓	-0-	98 ✓	104	102 ✓	26	103.7 @ 4:02
4:10	All Furnaces Off - Continue Helium Flow																

NOTE: EXTREMELY STRONG FECES SMELL OUT OF GASIFIER

RUN #21 - UREA

ENTIRE RUN THRU REFORMER

Tare + Al₂O₃ | = 32.81 g
27.39
5.42
6.21
11.63
27.39
39.02
6.92
45.94 check

50 ml crucible 29.06 } 6.92
+ Urea 35.98 } 6.21
+ Al₂O₃ 42.19

Steam Reformation Data Sheet

Date: 4-19-96
Page: 1 of 2

Material Tested: BAKER UREA Batch 4204-01
Sample Weight:
Crucible Tare: 27.39
Tare + Al2O3: 39.02
Tare + Al2O3 + Sample: 45.94 check

After Test Weight = 37.82 g (all white, no black residue)

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871
Set Point #3: 871
Ice Bath: 0

Trap Weights: GASIFIER:
Water Gross: 1003.9
Water Tare: 976.1
20 Filter Gross: 0.06
14 Filter Tare: 0.06
PORE SIZE: 8μ

TRAP WEIGHTS REFORMER:
WATER GROSS 885.3
WATER TARE 853.1
FILTER GROSS 0.06 g
30 FILTER TARE 0.06 g
PORE SIZE: 8μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2-He Rotameter	O2 Rotameter	Pressure (psig)	Comments			
														P2	P3	P4	Burette
													P5	psig	psig	psig	
13:29	Furnaces ② & ③ on. – Start Chart																
13:29	Helium & O₂ on																
13:45	– 477.4	34 419.9	34 230.6	39 383.2	316.2	71.2	81	571	542	80	45	37	15	100	105	105	107	18.0 @ 13:37:20 22.5 @ 13:51:30
13:56	– 758.4	84 719.2	86 476.8	91 650.6	568.8	135.2	155	796	709	80	45	37	15	99	104	104	106	31 @ 13:58:30
14:00	Water Flow into Rig; FURNACE ① On																
14:01	– 819.3	111 821.6	112 580.7	126 737.9	651.7	172.9	257	859	771	77	135	37	15	100	106	107	108	37 @ 14:04
* 14:03	GC Sample of Reformer Effluent																
* 14:05	Bag Sample of Reformer Effluent																
to 14:07 14:07	–	149	151	159													
14:10	– 867.4	161 842.8	167 697.4	197 850.7	753.4	217.2	616	870	853	80	129	39	18	98	102	103	105	47 @ 14:13
*X 14:10 - :14	Bag Sample of Gasifier Effluent																
14:14	Flow back thru Reformer																
*** 14:17 -	Bag Sample of Reformer Effluent						(Took until 15:10 to fill bag)										
14:19	– 866.7	319 848.8	353 756.6	456 882.6	778.3	219.9	759	870	871	80	155	12	-0-	92	125	127	129	57.5 @ 14:22
14:24	– 864.5	497 849.7	509 771.3	562 882.3	779.2	231.7	760	872	875	80	155	10	-0-	88	131	131	133	65 @ 14:27
14:24:30	Cut water flow in Half (micrometer						@ .050" stroke)										
14:30	– 864.5	617 852.7	621 783.4	632 893.3	780.9	235.8	760	870	873	55	142	10	-0-	87	130	129	131	~~66~~ @ 14:32:30
14:34	Shut off water flow (Restore stroke						to 0.100" on micrometer – but dwell in bypass mode for awhile							⇒ burette = 68.6 14:35.45)			
14:39	– 863.1	684 854.9	686 796.4	689 842.6	775.5	231.0	759	871	874	80	38	33	14	88	107	107	109	76 @ 14:42
14:42	Cut feed water back into system																
14:44	– 863.2	702 855.5	703 801.6	707 874.4	775.3	218.0	761	872	874	75	142	18	2	91	121	122	124	81 @ 14:46:30
14:47:30	Cut feed water off																
14:55	861.3	723 859.0	724 811.8	729 896.8	774.0	215.5	761	871	871	80	38	34	15	89	104	105	108	93.5 @ 14:57:30
14:58	Cut feed water back in (still w/ 0.100" stroke)											10	-0-	91	130	130	132	
15:02	Cut feed water off again																
15:06	– 860.5	738 860.1	739 818.8	741 900.8	775.6	204.0	761	871	870	80	38	12	-0-	100	125	125	127	106.2 @ 15:08:30
* 15:11	GC Sample of Reformer w/o						Water										

go to page 2

Traps @ 0°C

← Reactor Plugg

14:07 - :14 flow thru gasifier only

to 14:24:30 normal
14:24:30 to 14:34 (½)
14:34 to 14:42 (0)

RUN #21 - UREA (cont)

Steam Reformation Data Sheet

$P^{\circ}_{He} = 130$
$P^{\circ}_{O_2} = 123$

Date: ____
Page: 2 of 2

Material Tested: ____
Sample Weight:
Crucible Tare: ____
Tare + Al2O3: ____
Tare + Al2O3 + Sample: ____

Set Temperatures:
Set Point #1: ____
Set Point #2: ____
Set Point #3: ____
Ice Bath: ____

Trap Weights:
Water Gross: ____
Water Tare: ____
Filter Gross: ____
Filter Tare: ____

Water [illegible]

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	N2/He Rotameter	O2 Rotameter	Pressure (psig)	Comments			
														P2	P3	P4	Burette
15:16	– 860.2	742 860.9	743 822.?	748 902.7	775.2 205.1	761	870	867	80	38	28 ✓	14 ✓	P5 97 ✓	111	112 ✓	115	118 @ 15:18:30
* 15:21 to 15:30	Bag sample of Reformer Effluent w/o Water								-								
15:25	–	747	749	752													
15:30	860.8	862.4	825.8	900.2	773.3 202.1	759	870	873	80	37	22 ✓ 22 22 ✓	4 ✓ 5 5 ✓	100 ✓ 100 101 ✓	116 115	117 ✓ 115 ✓	119 118	128 @ 15:27:15 137.5 @ 15:35:15
15:40	– 860.5	750 862.8	752 830.3	756 904.1	775.3 200.3	761	871	871	80	37	23 ✓	7 ✓	101 ✓	114	114 ✓	117	145 @ 15:42
* 15:53	GC sample of Reformer Effluent w/o Water Feed																
15:55	– 860.1	752 864.2	754 834.0	757 901.1	771.8 203.5	759	871	868	80	37	23 ✓	8 ✓	101 ✓	113	113 ✓	116	165 @ 15:57
16:11	– 860.1	754 865.2	756 836.6	760 904.8	775.2 204.5	761	871	868	80	37	25 ✓	13.5 ✓	101 ✓	112	113 ✓	115	181.5 @ 16:13
16:25	– 860.1	754 866.4	757 838.4	761 904.6	775.0 204.8	759 761	871 870	870 871	80	37	25 ✓	13.5 ✓	101 ✓	112	113 ✓	115	198 @ 16:27:30
16:28	Start water flow w/ 0.050" stroke																
16:30	water reaching system (takes >1 min to increase from 38 to 125 psi @ .050" stroke)																
16:34	– 860.8	759 866.9	760 839.7	761 905.6	776.0 203.8	761	871	868	54	135	15 ✓	20 ✓	101 ✓	123	124 ✓	128	204 @ 16:37:30
* 16:38	GC sample of Reformer Effluent with ½ water feed																
16:38:30											25 ✓	8 ✓	101	116	118 ✓	122	205 @ 16:39:30
16:42	Drop P5 to 70 psi																
16:47	Pressures still playing games – shut down water, increase helium & O2										P5 = 75, P2 = 125		P3 & P4 =	130 & 132			
16:48.	Stop water flow. Burette @ 210 cc Increase He flow																
16:56	– 859.1	751 865.9	754 841.4	760 905.3	775.7 207.9	759	870	866	–	–	54 ✓	21 ✓	75 ✓	124	122 ✓	126	
17:09	– 859.6	756 866.3	758 841.5	762 901.5	772.1 197.0	761	871	871	–	–	62 ✓	23 ✓	74 ✓	121	121 ✓	123	
* 17:22	GC sample of Reformer Effluent																
17:23	– 860.3	756 867.3	758 842.6	762 904.8	774.8 201.0	760	871	866	–	–	64 ✓	25 ✓	74 ✓	118	119 ✓	121	
17:29	– 857.6	756 867.2	758 842.9	762 905.1	775.1 201.3	760	870	867	–	–	65	25	73	118	118	120	
17:32	Rxl Furnaces Off																
17:34	O2 off																

RUN #22 - IGEPON TC-42

Steam Reformation Data Sheet

Date: 4/23/96
Page: 1 of 1

Material Tested: IGEPON TC-42 (GAF #81 - Recd 7/2/90)
Sample Weight:
Crucible Tare: 26.84
Tare + Al2O3: 43.27
Tare + Al2O3 + Sample: 50.31
7.04
Final Condition Clear, white Al_2O_3; Wt = 41.93 g OK (41.98 5-3-96)

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871 °C
Set Point #3: 871 °C
Ice Bath: 0 °C

Trap Weights; GASIFIER:
Water Gross: 997.4
Water Tare: 976.1
Filter Gross: 0.06
Filter Tare: 0.06
Pore size 8μ

Trap Weights; REFORMER
Water Gross: 877.6
Water Tare: 853.1
Filter Gross: 0.06
Filter Tare: 0.06
Pore size 8μ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ HE Rotameter	O2 Rotameter	Pressure (psig)	Comments			
													P5	P2	P3	P4	Burette
2:50	FURNACES ② & ③ ON: HELIUM @ 121 scc/min ON																
3:03	Flow thru REFORMER																
	-	33	34	38													
3:06	OXYGEN ON																
	-	53	55	59													
3:12	638.7	584.3	345.9	546.9	470.9	140.8	124	699	639	78	47	37	14.5	98	102	102	105	3.5 @ 3:15
3:18	-	74	77	82	?												
	771.0	723.3	473.6	660.0	585.7	292.6	164	808	717	80.5	47	37	14.5	98	103	103	105	10 @ 3:20:32
3:21	FURNACE ① on																12.5 @ 3:22:30
3:22:30	WATER ON																
	-	105	108	111													
3:24	855.5	813.4	580.7	750.7	673.3	181.9	341	871	784	77.5	135	36	14	98	104	103	107	
Leaky bag → * 3:26:30	BAG SAMPLE OF REFORMER (~150-160																
3:32:09	BAG SAMPLE OF GASIFIER (to 3:36:30)					Gasifier from ~3:30 to 3:37											
160°C 3:32	-	166	167	179													
	865.4	831.8	664.1	837.4	752.9	218.4	609	871	850	80	129	38	16.5	94	99	98	101	25.5 @ 3:34
3:37	Switch flow to REFORMER																
	-	214	223	349													
3:38	867.2	836.2	716.1	867.2	778.4	229.0	755	871	870	78	156	12	-0-	91	127	129	131	33.5 @ 3:42
* 3:42:30	BAG SAMPLE OF REFORMER (took all 3:55 to fill)																36. @ 3:44
3:44	Cut water stroke to 0.050" (Pressure up to 140 psig on P_3 & P_4); O_2 & HE not registering																
	-	457	470	517													
3:47:30	864.8	841.1	745.7	879.3	783.6	226.8	761	872	868	52	150	<0	<0	96	138	140	140	39. @ 3:50
3:53	-	622	626	639						54	150	<0	<0	96	136	137	139	
leaky bag → * 3:56	BAG SAMPLE OF REFORMER																
4:03	Cut water stroke to 0.040"																
	-	693	694	697													
4:04	862.8	847.6	773.9	883.8	781.8	231.2	759	869	871	50	144	<0	<0	88	134	135	137	45 @ 4:02:30
4:08	WATER OFF																
	-	723	723	724													
4:15	860.5	849.1	783.5	884.7	777.6	229.4	760	870	868	[8]	134	<0	<0	85	~~3:~~131	134	137	48 @ 4:17:30
* 4:19	VENT OVERPRESSURE CONDITION THRU GASIFIER DISCHARGE (~20 secs then back to reformer but filled ~~gas~~ Bag sample ~1/3)																
	-	733	732	733													
4:24	861.1	850.2	790.8	888.7	777.6	219.8	760	870	865	[10]	110	14	28	85	108	111	113	48 @ 4:26
4:33														89	118	117	120	48 @ 4:34
4:34	WATER BACK ON - stroke = .040"						(BAG SAMPLE @ 3:56 still not filled)										
	-	749	748	749													
4:42	860.9	851.6	800.1	888.8	775.8	216.2	760	872	875	47	142	<0	<0	96	131	132	134	52 @ 4:44
4:46	Blowdown to 60psi to fill 3:56 bag																53.5 @ 4:48
* 4:48	WATER OFF AGAIN; BAG SAMPLE OF REFORMER						(4:50)										
~~5:00~~	Blowdown to 36 psig to fill 4:48 BAG																
4:55	~~FURNACES OFF~~ Breakthru? Helium						& O_2 flows back on? No consequence of water off ⇒							27	100	100	103	
	-	748	748	751								40	20					
5:03	858.4	854.0	809.7	888.3	774.3	210.8	760	871	872	-	-	40	22	41	98	98	101	54 @ 5:05:30
5:06	FURNACES OFF																

5:09 O_2 off
5:16 Helium off

RUN #23 - REFEREE MIX

Steam Reformation Data Sheet

Date: 4/30/96
Page: 1 of 1

Material Tested: 5-Component Mix
Sample Weight:
Crucible Tare: 27.12) 5.23 g Al_2O_3
Tare + Al2O3: 32.35) 10.11 g Ref
Tare + Al2O3 + Sample: 42.46) (6.18 g Dry wt)
Wt after run 32.06 g
Traces of unburned plastic (took photo)

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871
Set Point #3: 871
Ice Bath: 0

Trap Weights; GASIFIER
Water Gross: 1003.7
Water Tare: 976.0
Filter Gross: 0.06
Filter Tare: 0.06
Pore size: 8 µ

TRAP WEIGHTS, REFORMER
Water Gross 890.1
Water Tare 853.0
Filter Gross 0.06
Filter Tare 0.06
Pore Size 8 µ

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ HE Rotameter	O2 Rotameter	Pressure (psig)	Comments P_2	P_3	P_4	Burette
2:00	FURNACES ② & ③ ON : N_2 Flow					ON	P_S = 98 psi						P_i				
2:16	− 39 41 43 478.9 449.7 265.0 439.7 351.7 65.0					66	578	549	81	77	36 ✓	14 ✓	96 ✓	100	100 ✓	102	38 @ 2:18:30
2:15 ~~2:16~~ 2:25	O_2 ON − 71 73 76 731.6 708.4 461.4 667.8 572.2 110.3					112	772	695	81	79	36 ✓	14 ✓	98 ✓	102	102 ✓	104	47.5 @ 2:27:00
2:30 ✓	Water on (stroke = 0.100") P_{water} →					138 psi											
2:32	− 113 116 123 857.9 838.9 609.6 791.8 692.1 117.2					159	871	785	81	137	36 ✓	14 ✓	96 ✓	102	102 ✓	104	55.5 @ 2:34:00
2:37 ✓	FURNACE ① ON																
2:38	− 163 165 174 870.2 857.1 701.8 877.2 767.9 133.4					264	870	853	81	137	37 ✓	14.5 ✓	96 ✓	102	102 ✓	104	63.6 @ 2:40:30
* 2:41 ✓	G.C. of Reformer																
2:42 ✓	Switch flow to Gasifier Discharge																
* 2:45 ✓	Bag Sample of Gasifier (2:45 − 2:51)																
2:46	− 161 156 166 869.4 865.6 770.3 913.5 175.5 161.6					581	871	871	81	137	36.5 ✓	14.5 —	96 ✓	100	101 ✓	103	72 @ 2:48:30
2:50	− 157 145 156																
* 2:55 ✓	Bag Sample of Reformer (2:55 − 2:57) ← 2:51 ✓ Switch flow to Reformer																
2:57	Switch flow back to Gasifier																
2:58	− 552 562 512 868.6 871.4 815.6 921.5 175.2 151.4					757	871	867	81	137	36 ✓	14 ✓	96 ✓	100	101 ✓	104	86 @ 3:01:
* 2:59 ✓	Bag sample of Gasifier (2:59 − 3:04)																
3:04	Switch flow to Reformer																
3:05	− 680 653 652 867.2 873.2 829.0 [illegible] 791.6 136.6					760	873	873	81	137	35	14	98 ✓	102	103 ✓	105	93 @ 3:07:00
* 3:08	Bag Sample of Reformer (3:08:15 to 3:11)																
3:12	switch flow to gasifier																
3:13	− 718 717 704 866.3 875.5 839.2 927.8 789.2 163.7					760	872	867	81	137	36 ✓	14.5 ✓					
* 3:15 ✓	Gasifier GC @ 3:15																
3:16	switch flow back to reformer																
3:17	− 748 715 715 866.4 875.8 843.1 928.0 789.6 147.3					761	872	873	81	137	37 ✓	14 ✓	97 ✓	102	102 ✓	104	107 @ 3:19:30
3:21	O_2 off																115.5 @ 3:24:00
3:21	FURNACES OFF																
3:26	water off																
3:30	− 713 707 719 812.6 820.8 782.1 784.3 638.8 121.9 ~~50~~					715	809	716	--	10	40	0	88	92	93	33	

RUN #24 - REFEREE MIX

Steam Reformation Data Sheet

Date: 5-3-96
Page: 1 of 1

Material Tested: 5-Component Mix
Sample Weight:
Crucible Tare: 27.12
Tare + Al2O3: 32.07
Tare + Al2O3 + Sample: 42.29
{Residual from Run #23, Used same crucible
Final Weight = 32.28 g (10.22 (wt) → 6.24 g dry wt) (some charred mat'l visible)

Set Temperatures:
Set Point #1: 760 °C
Set Point #2: 871
Set Point #3: 871
Ice Bath: 0

Trap Weights, GASIFIER
Water Gross: ~~[illegible]~~ 1025.3
Water Tare: 976.1
Filter Gross: 0.065
Filter Tare: 0.06
Pore size: 8μ

TRAP WEIGHTS, REFORMER
Water Gross 906.8
Water Tare 853.1
Filter Gross 0.055
Filter Tare 0.06
Pore size: 8μ

O2 on approx 2:17

Time (hr:min)	TC #1 (deg C)	TC #2 (deg C)	TC #3 (deg C)	TC #4 (deg C)	TC #5 (deg C)	T1 (deg C)	T2 (deg C)	T3 (deg C)	Water Rotameter	Water P (psig)	~~N2~~ HE Rotameter	O2 Rotameter	Pressure (psig)	Comments			
													P5	P2	P3	P4	Burette
2:05	FURNACES ② & ③																
2:15	–	24	24	29													
2:16	300.2	255.9	118.8	254.4	175.6	42.5	52	449	436	81	103	38 ✓	–	96 ✓	99	100 ✓	30	43 @ 2:20:00
2:24	–	46	45	52													
	567.1	517.9	257.6	507.9	423.9	61.8	91	634	594	81	102	38 ✓	14 ✓	95 ✓	99	100 ✓	102	51 ✓ 2:26:30
2:33	–	103	101	113													
	783.3	744.0	446.8	703.6	611.8	84.1	149	813	723	81	112	38 ✓	14 ✓	96 ✓	99	100 ✓	102	61 ✓ 2:35:30
2:36	Flow switched to gasifier																
2:36:30	Water Flow On																
2:39	–	138	138	143													
	823.4	827.6	541.2	782.2	685.2	96.3	183	866	781	78	142	38 ✓	14 ✓	98 ✓	101	101 ✓	103	67 2:40:30
2:42 ✓	FURNACE ① ON																
	~~G.C. sample of GASIFIER FLOW~~																
2:46	–	164	166	173													
	871.6	846.4	637.1	878.7	772.2	113.3	400	873	855	81	143	38 ✓	14.5 ✓	97 ✓	101	101 ✓	103	75 @ 2:48:00
* 2:49 ✓	G.C. Sample of GASIFIER FLOW																
* 2:53 ✓	BAG SAMPLE OF REFORMER (2:53 to																
2:55	–	206	172	291													
	871.4	853.5	712.7	875.9	787.1	159.8	690	872	865	81	150	37 ✓	14.5 ✓	97 ✓	101	101 ✓	104	86 @ 2:57:30
* 2:59 ✓	BAG SAMPLE OF GASIFIER (2:59 to					3:02											
3:00	–	516	502	554													
3:02	switch flow back to REFORMER																
* 3:04 ✓	BAG SAMPLE OF REFORMER (3:04 to					3:08)											
3:05 ✓	–	632	630	644													
3:09	switch flow back to gasifier																
* 3:11 ✓	BAG SAMPLE OF GASIFIER (3:11 to					3:17)											
3:15	–	714	709	703													
	872.7	863.1	762.3	911.1	785.9	126.4	760	869	873	81	150	38 ✓	14.5 ✓	97 ✓	101	101 ✓	104	110.5 @ 3:19:00
3:18	Switch flow back to REFORMER																
* 3:23 ✓	G.C. Sample of REFORMER																
3:31	–	751	750	740													
	869.9	868.8	788.0	911.1	781.4	156.7	758	871	866	80.5	153	38 ✓	14 ✓	97 ✓	100	101 ✓	104	127 @ 3:35:30
3:40	–	722	733	740													
	869.6	870.7	798.2	912.9	782.0	157.8	761	869	868	80	155	38.5 ✓	14.5 ✓	96 ✓	100	100 ✓	103	137.5 @ 3:42:30
3:46	switch flow to gasifier																
3:48	–	743	745	745													
	867.3	869.9	801.4	913.9	779.6	152.6	761	871	869	80	153	38.5 ✓	14 ✓	98 ✓	101	101 ✓	104	147 @ 3:50:30
* 3:58	G.C. Sample of GASIFIER																
3:59	O_2 OFF																
4:00	FURNACES OFF																
4:01	–	748	751	749													
	860.6	865.5	805.3	896.0	759.4	108.9	749	854	831	80	155	38.5	-0-	97	100	100	37	161.5 @ 4:03:30
4:04 ✓	WATER OFF																

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The purpose of this program is to evaluate the feasibility of steam reforming spacecraft wastes into simple recyclable inorganic salts, carbon dioxide and water. Model waste compounds included cellulose, urea, methionine, Igapon TC-42, and high density polyethylenes. These are compounds found in urine, feces, hygiene water, etc. The gasification and steam reforming process used the addition of heat and low quantities of oxygen to oxidize and reduce the model compounds.The studied reactions were aimed at recovery of inorganic residues that can be recycled into a closed biologic system. Results indicate that even at very low concentrations of oxygen (<3%) the formation of a carbonaceous residue was suppressed. The use of a nickel/cobalt reforming catalyst at reaction temperature of 1600 degrees yielded an efficient destruction of the organic effluents, including methane and ammonia. Additionally, the reforming process with nickel/cobalt catalyst diminished the noxious odors associated with butyric acid, methionine and plastics.

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