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A Comparison between two Lysholm engines.

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ABSTRACT

The University of California at Berkeley (UCB) and the Jet Propulsion Laboratory (JPL) both have been working on the Lysholm engine as an expander of two phase geothermal brine. The sizes of the machines, (The machine at UCB is rated at 25 Kw, and the machine that JPL tested is rated at 1Mw) as well as the approaches, are different. Here, some comparisons are made in order to clarify the direction in which future efforts should be conducted.

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1. Introduction.

Steam generated from geothermal reservoirs has the potential to generate important amounts of electric power. Unfortunately, reservoirs which produce dry steam are very rare. Most produce hot water or a mixture of hot water and steam. Two ways to use this mixture are to flash it to a lower pressure and higher quality before separating steam and water, and to use a binary cycle with a more thermodynamically suitable working fluid. Both methods involve a loss of some of the available energy of the steam in the wellhead.

The Helical Screw Expander (HSE), being an engine that can work with two phase flow, uses both the steam and the hot water available in the reservoir. It is well known as an air compressor. Two helical screw rotors (male with four lobes and female with six) intermesh forming one boundary of the chamber in which a two phase mixture is enclosed, with the case and the rotors forming second and third chamber boundaries and the end plates forming the final chamber boundary. When the fluids enters the inlet port, it fills a volume of, say, X cubic centimeters (the volume of the chamber described). The fluid expands, turning the rotor and increasing the volume to, say, Y cubic centimeters. This expansion provides the energy available as shaft power. The ratio Y/X is called volume ratio and it is defined by the end plates. This ratio was recently modified by Michael

Dunbar for the expander currently being tested at the University of California at Berkeley (UCB), to study how the efficiency varies with it.

2. Description of the machines.

2.1. UCB engine.

In this report, three machines are going to be considered.

- a) The 1 Mw expander built by the Hydrothermal Power Co. (HPC) and tested by the Jet Propulsion Laboratory (JPL)
- b) A 25 Kw expander previously tested by HPC.
- c) A 25 Kw expander currently being tested at UCB.

a) and c) were originally designed as expanders, b) was an adapted air compressor. The 25 Kw expander currently being tested at UCB, has been extensively studied and it is described in detail in most of the references. During the tests run by HPC on their small expander, efficiencies as high as 65 and 74 % were claimed. However, power losses of the load train were not accurately known, and these losses did affect the calculation of efficiency. These numbers are in open contradiction with other data taken on the 25 Kw machine at the Lawrence Livermore National Laboratory (LLNL), where the highest efficiency registered was 55%, and at the Department of Mechanical Engineering at UCB, where the highest efficiencies registered are in the order of 43%.

A statement is made in the final report published by JPL (Ref. 1), that we find important. There it is said that "The testing of such a machine (the 25 Kw expander or any other small expander) could produce misleading results". The important of this will be clear when we see that both groups of data seem to show important differences on which are the important variables which define efficiency. According to the JPL study, efficiency has no important dependance on pressure ratio. This contradicts UCB results.

2.2. JPL engine.

The portable expander was tested by the JPL in a program sponsored by the Department of Energy (DOE). The unit includes a 1 Mw variable load bank. Design details are proprietary and were not disclosed, so only some basic information can be given here. The rotors are 63.5 cm (25 in) long and the diameter is 41.9 cm (16.5 in). These measurements are known.

The geothermal well to be used to provide the two phase mixture needed to fill the following requirements:

- 1) Low salinity: it was decided to test the machine with low salinity brine at first, and only in a second stage with high salinity brine as the one available in Salton Sea KGRA. (Known Geothermal Resource Area). This stage was never accomplished.
- 2) High rate of production: A 1 Mw expander at 70%

efficiency requires approximately 250000 Kg/h of saturated brine for 690 MPa (100 psia) inlet, noncondensing operation, under full load.

The selected sites were Roosevelt KGRA Well 54-3 in Utah, owned by Philips Petroleum Co. (PPC), and Well M-10 in Cerro Prieto, Mexico. The tests were conducted over 437 hours in Utah, at an altitude of 1859 m (6100 foot) and over 1101 hours in Cerro Prieto. The conditions included inlet pressure ranging from 579 MPa (84 psia) to 1779 MPa (258 psia), inlet quality 0 to 99 %, linear throttle position 7 to 100 % open, output shaft load 0 to 1059 Kw with male rotor speed of 3000 rpm. A few data points were taken at 4000 rpm. Exhaust pressure was atmospheric at 83 MPa (12 psia), except for a few tests performed at exhaust pressures of 186 MPa (27 psia) to 207 MPa (30 psia). However, we have not used all these data points for reasons that will later be explained.

At this time, it is important to explain the differences in the objectives of the two programs. At UCB, the expander was tested with the objective of obtaining the highest possible output from the resource available, or, in other words, the prime objective was obtaining the highest system efficiency of the whole geothermal power plant. Use of the Lysholm engine would be as a candidate for a topping system of a conventional steam power plant. For the JPL program, the prime objective was the reduction of the

capital cost per unit of power, the system efficiency being a secondary objective. From the point of view of conservation of an exhaustable resource, the first approach would be preferred, but from a strictly economic point of view, an analysis in which the figure of merit is cost per unit of energy produced, (cents/Kwh). The decision is not obvious and should be preceded by an economical analysis.

Some specific comments must be made about deposited scale. The expander was designed with an allowance for scale deposit, so, clearances were larger than they would have been if the scale deposit were not expected. Without scale being deposited, the machine is unfinished, in a sense. The explanation is that the recorded performance is lower than the one that could be reached with scale. However, the hopes placed by HPC in the improvement of efficiency by deposition of scale could prove unrealistic since:

- 1) The HPC predicted that there would be scale deposits, an opinion that went against the one by PPC. PPC said that scale deposits would not take place, and they did not.
- 2) If scale deposits were produced, they would appear in the last part of the expansion, and not in the first part, where most of the energy is developed, making it difficult to believe that any very significant improvements can be reached. If this hypothesis proved to be true, designing the expander with big clearances, hoping that they will be reduced by scale deposit, would be a design mistake.
- 3) When the expander at UCB was disassembled for the first

time, in December 1982, after running for several hundred hours over six years, only minor scaling was observed, and that in the low pressure end. (figure 9). However, it must be realized that at UCB the machine was tested with relatively clean steam (steam from a boiler), and one can not expect to find the same amount of deposited scale that would occur if the machine had been run with steam from a natural reservoir.

HPC's theory is alleged to be proved by the fact that an efficiency of 62 % was reached in Mexico, where the machine was taken after having being tested in Utah. The improvement was credited to deposited scale. Caution should be exercised when reading these data, however, since only a few data points gave so high efficiencies.

To encourage deposits, calcium chloride was injected in the inlet of the expander, but scale still was not deposited, possibly because of the scale inhibitors injected into the fluids at the wellhead by PPC during much of the testing. It is not clear why PPC did this, but it must be kept in mind that PPC was running other programs in the area at the same time. (Evaluation of the geothermal wellheads).

One of the objectives of the JPL program was to gain experience to be used in a larger machine. A 5 Mw machine has been planned but not built. Another objective was to study the behavior of the Lysholm machine under different operating conditions, and even if this objective is claimed,

we will see that most of the data obtained are over a limited variation of the parameters.

3. Performance evaluation.

3.1. Theory.

3.1.1. Efficiency:

For the purpose of performance evaluation of the expander, the engine efficiency is defined as:

$$\eta = \frac{P}{\dot{m}(h_1 - h_{2s})}$$

where:

P = shaft output power. (Kw)

$\dot{m}$ = flow of fluid through the expander. Kg/s (lbm/s)

h_1 = specific enthalpy of fluid entering the HSE at inlet pressure P1 and inlet temperature T1. Kj/Kg (Btu/lbm)

and

h_{2s} = specific enthalpy which would result from the isentropic expansion of the fluid from the inlet condition to the outlet pressure P2 Kj/Kg (Btu/lbm).

The value of h_{2s} is calculated from h_1 and the thermodynamic properties of the fluid at the inlet and outlet pressures.

P , $\dot{m}$, and h_1 are determined experimentally, which means that the engine efficiency accounts for all the losses between inlet and outlet, whether thermal, thermodynamic, mechanical or electrical. The thermal losses could be calculated theoretically and added to the output of the expander. This would be the case if the machine were thermally insulated as the one at JPL was. The expander at UCB was not insulated and no provisions were made to take these losses into account. However, they are estimated to be small.

Transmission losses, the gear box in JPL engine and the belt in UCB engine, as well as electrical losses, the alternator in JPL engine, can reasonably be added to the output. These differences impair the comparison between machines, since both losses were taken into account at JPL. The losses in the gear box were calculated theoretically and the losses in the alternator were measured, but the belt losses were not included in calculations at UCB.

3.1.2. Volume ratio:

As it was defined above, the volume ratio (vr) is the ratio of the volume occupied by the fluid before exiting (volume of the outlet chamber) over the volume of the inlet chamber. It does not depend on the operating conditions but on the design. It should not be confused with the ratio of specific volumes.

3.1.3. Ratio of specific volumes:

The ratio of specific volumes (rsv) is the ratio of the specific volume of the mixture at the exhaust pressure over the specific volume at the inlet pressure. It depends on the operating conditions. Since the Lysholm expander is a positive displacement machine, the rsv was thought to be more significant than the pressure ratio (exhaust pressure over inlet pressure). However, the use of the rsv as independent variable instead of the pressure ratio, did not yield any further information.

3.2. Test process fundamentals.

At Berkeley, the shaft power is the product of the torque and rpm as measured by specific transducers attached to the machine. For the JPL tested, the power was measured at the alternator. This was corrected for losses at the gear box and at the alternator. As stated, the gear boxes losses were calculated using the theory of gears and the alternator losses were actually measured before installation.

The inlet enthalpy h_1 must be determined indirectly and, in the case of two-phase flow, the flow rate $\dot{m}$ is also an indirect measurement. These two quantities can be determined by measurements made either upstream or downstream from the expander. Upstream, the two phase flow exists as separated steam and liquid streams, which flow rates and enthalpies can be measured. The two streams are recombined

after the measurements have been made. The flow rate of the two phase flow is assumed to be the linear sum of the two.

$$\dot{m} = \dot{m}_g + \dot{m}_f \quad \text{and} \quad \dot{m} h = \dot{m}_g h_g + \dot{m}_f h_f$$

or

$$h = (\dot{m}_f h_f + \dot{m}_g h_g) / (\dot{m}_g + \dot{m}_f)$$

Where g refers to the vapor stream and f to the liquid stream.

The calculation of the efficiency by downstream measurement is:

$$P + \text{losses} = \dot{m} (h_1 - h_2)$$

thus

$$h_1 = h_2 + (P + \text{losses}) / \dot{m}$$

and here thermal losses were neglected.

As in the case of upstream measurement, the stream can be separated in its liquid and steam components and h_2 and $\dot{m}$ can be determined, or the two-phase vapor can be condensed to a single phase and weighed.

This latter treatment is compatible with the use of a contact condenser for vacuum operation.

In order to determine if the losses in the throttle or flow control valve, were significant, pressure was measured upstream and downstream from the valve. We have taken the

downstream value for the calculations, but there is not a very significant difference between both values.

It was observed that under high loads, the measured exhaust pressure varied erratically, perhaps from buffeting by exhaust fluids issuing underexpanded from the exhaust ports. When this happened, the exhaust state was calculated taking the exhaust temperature T2 rather than the pressure.

3.3. Process options.

Among the many process options available and described in the report, we will consider only two. Both were actually used.

3.3.1. Process 1:

In process 1 (figure 1), the inlet fluid to the expander is at a constant enthalpy, determined by the well. Pressure is varied by the pressure control valve. Clearly, the process lacks versatility, since enthalpy is constant, but it is simple and inexpensive. (Enthalpy could be changed by installing a fractionator between the well and the expander).

The expander exhaust is separated into vapor and liquid streams for measurement. This process requires a separator, but no cooling water or additional equipment. This process was used for the 1980 tests in Mexico.

3.3.2. Process 2:

Because this was the process actually used in Utah, where most of the data were taken, it will be discussed in detail.

In this process (figure 2), the exhaust from the expander at atmospheric pressure flows to a waste tank where the vapor is vented to the atmosphere. Liquid flows by gravity to a pump for repressurization, so that waste water can be injected into the disposal line, downstream from the point at which it was taken for use by the expander. This pressurized waste water provides a supply of low temperature water (approximately 93 C (200 F)) which can be injected in small amounts into the feedline to the expander, at a suitable distance upstream from the orifice meter, to lower the temperature of the feed stream and ensure against flashing in the orifice. This could happen because of the combined effects of the pressure loss and an elevation of 5.5 m (18 feet) of the feed pipe above the expander. By increasing the recycled waste water flow, it is possible to lower the enthalpy of the free stream sufficiently to prevent flashing before the pressure control valve. Figure 3 is approximately to relative scale and more complete. It also shows the points of measurement. 15.2 cm (6 in) pipe was used throughout most of the facility. Exceptions include a 63.5 cm (24in) diameter exhaust pipe from the expander to the first waste tank, 25.4 cm (10 in) diameter pipe for the wastewater from the tanks to the pumps, and 10.2 cm (4 in)

diameter runs for the vortex-shedding flow meters in the pump discharge system.

The purpose of the mist separator, shown in figure 3, is to ensure that the vapor measured was dry. P_f , T_f , P_v and T_v , were measured at the end of the feed lines, just before mixing.

4. Test results.

As described, not all JPL data were accepted for our comparisons for the following reasons:

1) There were three observations at high qualities (99% vapor).

2) Some data points were measured at exhaust pressures higher than atmospheric. Because of the altitude, (1859 m (6100 feet)) atmospheric pressure was about 83 MPa (12 psia). All the data accepted have an exhaust pressure between 75 (10.8 psia) and 91 MPa (13.2 psia). Among the other data points, there are:

22 data points at exhaust pressures varying from 172.5 MPa (25 psia) to 276 MPa (40 psia).

15 data points at exhaust pressures varying from 104 MPa (15 psia) to 110.4 (16 psia). The range of variation is so small in this set of data, that many points are really repetitions of another data point. These data were recorded in Mexico.

The reason that we kept only atmospheric exhaust data is that we want to compare the results with the ones for the 25

Kw expander tested at UCB, and it was found that for two phase machines at least one dimensional (or dimensionless) parameter related to exhaust pressure is necessary to ensure similarity. We will see that one is probably not enough. Unfortunately, implementing this criterion means that the data points with the highest claimed efficiencies are excluded.

3) A few data points were measured at speeds different from 3000 rpm. They were also neglected. This is regrettable, because information could be derived by observing the performance data at other speeds, the most obvious observation being an optimum speed. Among these data points, we have:

9 data points at 4000 rpm and with exhaust pressures varying between 172.5 MPa (25 psia) and 276 MPa (40 psia).

12 data points at 4000 rpm and inlet pressures varying from 104 MPa (15 psia) to 107.5 MPa (15.4 psia).

130 data points were accepted, 84 were not.

In Table 1, the accepted data are presented. They are ordered with increasing inlet quality. To visualize the behavior, some graphs were made and are presented in the appendix. The independent variable selected was pressure ratio, the dependent parameters graphed are exhaust quality, efficiency, mass flow and power. All these graphs were made for each value of inlet quality, which is the other independent variable. Analyzing these graphs, two probably wrong points were detected, the fact that they are consecutive supports this hypothesis. Only the graphs for $q_1 = 15, 20$ and

25 % are presented here, because those can be compared with the ones at 17 and 25 % for the 25 Kw machine at UCB. (Ref 2).

Power was also taken as an independent variable and efficiency, flow rate, and specific flow rate (lbs/kwh), were measured against it. These graphs show that many data points are essentially a single data point taken many times. With this repetition of data, for some inlet qualities there are not enough data points to describe performance.

One of the most surprising claims in the JPL report is that efficiency is a weak function of pressure ratio. This is approximately true in the range of pressure ratios in which the machine was tested, but is difficult to extend this conclusion to all pressure ratios, since the range of variation is not very wide, and since the dependence of efficiency on pressure ratio is more pronounced at low pressure ratios than at higher pressure ratios. At UCB, efficiency was found to be dependent on pressure ratio.

Here, it is interesting to consider the way the data are presented in JPL report. Efficiency is assumed to be the product of three functions; power, inlet quality and pressure ratio. This is proved by graphing efficiency over the product of these three functions against the per cent of throttle. If the data are close to the line $y = 1$, as does happen, the hypothesis is presumed correct (Figure 4). One advantage of this presentation is that each relation is

reduced to only one graph, instead of having one graph for each value of quality or pressure ratio. Now, it is clear that by graphing efficiency over the product of two functions, the influence of the third function can be visualized. This is done for the power, (Figure 5) and it can be observed that efficiency is a strong function of power, as it was expected.

The data selected were also processed in this way, with the functions of power, pressure ratio and quality being:

$$f(Kw) = -21.36 + 10.25 * \log(Kw) - 0.072 * (\text{abs}(Kw - 520))^{**0.6}$$

$$f(pr) = 1 - 0.019 * (pr - 15)$$

$$f(q) = 1 - 0.54 * ((q - 41)/100)^{**3} + 0.0004 * (q - 28)$$

The value of these functions and the correlations are presented in table 2. We see that, as expected, the correlation for power is very different from 1, but, even if the correlation for the pressure ratio is close to 1, it varies by as much as 50 %. In Figure 6, we can see that the variation is about 43%. So, this variation, plus the fact that the interval of variation of the pressure ratio is not wide, do question the JPL conclusion about the weak dependence of efficiency on pressure ratio. At least, there are not enough elements to reach the definite conclusion stated.

It is interesting to further consider the consequence of the validity of the statement. If efficiency does not

vary with pressure ratio, it would be better to use the machine for high pressure ratios and obtain the maximum yield from the resource. This would support the argument implied by HPC. It remains to be proved.

An attempt was made to graph constant efficiency as a function of specific speed and specific diameter (Balje's diagram) (Figure 7) but the dependence was erratic. This diagram should be compared with the one for the 25 Kw machine at UCB (Ref 5) (Figure 8).

In this figure, the red rectangle represents the range of variation of HPC data, the blue rectangle represents the range of variation of the prior data taken at UCB, and the black rectangle represents the data taken for this project. (These data are in table 3). Keep in mind that previous data taken at UCB were taken at higher exhaust pressures and so can not be used for comparisons. The shadowed rectangle is the range in which comparisons can be made.

The plot of efficiency against pressure ratio (Figure 10) shows that the efficiency for both machines, (HPC and the one at UCB) is of the same order for similar specific speeds, making the comparison meaningful. However, this should be considered carefully because:

- 1) The overlapping in specific speeds is small.
- 2) The overlapping in pressure ratios is small.

It must be noted that higher pressure ratios could not be reached at UCB because of the piping layout. In order to

get lower exhaust pressures and higher pressure ratios, the layout would have to be modified and neither space nor money were available.

As the value of the ratio of exhaust volume over inlet volume for HPC machine was not stated, an attempt was made to estimate it. The inlet volume could have been easily estimated, assuming that it was geometrically similar to the one of the UCB machine. The exhaust volume could be estimated using the fact that the mass flow rate reaches an asymptotic value as a function of the pressure ratio. However, this fact was not observed for the HPC's machine.

Balje's diagram for the big machine suggests that not even specific speed, specific diameter and a parameter related to the exhaust pressure are enough to define the operating point of a Lysholm expander.

5. Conclusions.

1) The Lysholm tests should continue, trying with, this time, a wider range of variation of the parameters involved as an objective. In particular, different speeds should be tried to determine if an optimum speed exists and what that speed would be.

2) Special attention should be given to the problem of scaling. Studies should be made to know if scaling is to be expected, where, and how big the clearances should be. As it

was said, expecting that scaling could reduce large clearances can be an irreparable mistake, once the machine is designed.

3) As it is probably not very expensive to find a turbine to work in series with the Lysholm engine (at least, not as expensive as making the Lysholm), testing of staging at the 1 Mw scale could be considered.

4) An economic evaluation of both approaches should be conducted before decisions of new investments are made.

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2 Process Ner. 2, used in Utah.

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5 Coefficient of correlation for power.

6 Coefficient of correlation for the pressure ratio.

7 Balje's diagram for the 1 Mw expander.

8 Balje's diagram for the 25 Kw expander.

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10 Efficiency as a function of pressure ratio for HPC machine
and UCB machine.

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Table 1 Initial data, ordered with increasing inlet quality.

2 Coefficients of correlation.

3 Data taken at UCB for this project.

Appendix.

FIGURE 1.

FIGURE 3. SITE SCHEMATIC

As of
5/23/78

Figure 4 Efficiency Correlation versus Throttle Position

Figure 5 Correlated Efficiency versus Shaft Output Power

Figure *e* Efficiency Correlation versus Pressure Ratio

?

Steidel - Fig. 26

FIGURE 8

FIGURE 9

EFFICIENCY VS. PRESSURE RATIO. BOTH MACHINES

■ HPC
● UCB

FIGURE 10

■ HPC

$\alpha = 15$

EFFICIENCY VS. POWER

EFFICIENCY VS. POWER

EFFICIENCY VS. POWER

EFFICIENCY VS. V_2/V_1 FOR CONSTANT QUALITY

efficiency

ratio of volumes

EFFICIENCY VS. U_2/U_1 FOR CONSTANT QUALITY

EXHAUST QUALITY VS. V_2/V_1 FOR CONSTANT QUALITY

EXHAUST QUALITY VS. V_2/V_1 FOR CONSTANT QUALITY

EXHAUST QUALITY VS. v_2/v_1 FOR CONSTANT QUALITY

MASS FLOW VS. v_2/v_1 FOR CONSTANT QUALITY

MASS FLOW VS. V_2/V_1 FOR CONSTANT QUALITY

MASS FLOW VS. V_2/V_1 FOR CONSTANT QUALITY

POWER VS. V_2/V_1 FOR CONSTANT QUALITY

$\eta = 20\%$

POWER VS. V_2/V_1 FOR CONSTANT QUALITY

6-2576

POWER VS. U_2/U_1 FOR CONSTANT QUALITY

QD 15%

MASS FLOW VS. PRESSURE RATIO FOR CONSTANT QUALITY

x

MASS FLOW VS. PRESSURE RATIO FOR CONSTANT QUALITY

MASS FLOW VS. PRESSURE RATIO FOR CONSTANT QUALITY

POWER VS. PRESSURE RATIO FOR CONSTANT QUALITY

POWER VS. PRESSURE RATIO FOR CONSTANT QUALITY

$Q = 2.5$

POWER VS. PRESSURE RATIO FOR CONSTANT QUALITY

EXHAUST QUALITY VS. PRESSURE RATIO FOR CONSTANT QUALITY

EXHAUST QUALITY VS. PRESSURE RATIO FOR CONSTANT QUALITY

EXHAUST QUALITY VS. PRESSURE RATIO FOR CONSTANT QUALITY

EFFICIENCY VS. PRESSURE RATIO FOR CONSTANT QUALITY

EFFICIENCY VS. PRESSURE RATIO FOR CONSTANT QUALITY

EFFICIENCY VS. PRESSURE RATIO FOR CONSTANT QUALITY

FLOW RATE VS. POWER

Q = 15%

ESPECIFIC FLOW VS. POWER

FLOW RATE VS. POWER

Q=20%

ESPECIFIC FLOW VS. POWER

FLOW RATE VS. POWER

ESPECIFIC FLOW VS. POWER

TABLE I

q1	h1(Btu/lb)	Kw	eff	p2(psia)	p1(psia)	lbs/s	lbs/Kwh	Nd	Ns
0.005	357.3	328.0	36.4	11.7	195.2	36.4	400.	1.12	26.67
0.008	383.4	657.0	37.3	12.3	257.5	57.0	313.	0.90	29.65
0.008	383.3	661.0	37.7	11.9	256.5	57.4	313.	0.89	30.17
0.008	313.0	181.0	29.6	12.0	109.8	41.9	833.	1.03	37.73
0.008	383.6	657.0	37.8	13.0	257.7	57.0	313.	0.90	29.70
0.008	382.6	429.0	37.0	12.4	250.9	42.4	313.	1.05	25.32
0.010	321.9	230.0	32.4	11.9	120.4	42.6	667.	1.03	35.22
0.012	381.6	438.0	38.1	12.0	238.8	38.0	313.	1.09	24.63
0.013	319.6	394.0	39.6	12.4	112.8	60.8	556.	0.87	41.96
0.014	364.1	420.0	38.1	12.0	193.4	43.2	370.	1.02	28.74
0.014	382.1	438.0	38.1	12.0	236.1	38.0	313.	1.09	24.66
0.014	381.7	438.0	38.1	12.0	234.1	38.0	313.	1.09	24.63
0.015	319.9	394.0	39.4	12.4	111.7	60.8	556.	0.87	41.83
0.015	382.2	435.0	37.9	12.0	234.1	37.8	313.	1.10	24.50
0.015	379.2	398.0	37.3	11.9	225.2	36.9	333.	1.10	25.00
0.016	381.6	439.0	37.4	12.0	230.7	39.3	323.	1.07	25.32
0.016	319.7	122.0	25.1	12.0	109.8	30.8	909.	1.20	31.00
0.019	381.5	433.0	36.2	11.9	223.7	40.1	333.	1.06	25.60
0.022	337.8	394.0	37.2	11.8	128.7	54.7	500.	0.90	37.45
0.025	326.0	392.0	40.8	12.3	107.7	57.3	526.	0.88	40.97
0.026	324.7	345.0	38.6	12.0	104.1	53.2	556.	0.92	39.48
0.027	326.3	392.0	40.5	12.3	105.6	57.3	526.	0.88	40.77
0.031	364.4	425.0	39.6	12.0	162.5	43.7	370.	1.00	29.87
0.033	361.4	225.0	34.5	11.9	155.0	26.0	417.	1.32	22.51
0.035	360.3	563.0	42.1	12.6	188.5	47.4	303.	0.97	28.75
0.036	372.9	220.0	33.1	11.7	172.0	24.4	400.	1.35	21.14
0.039	380.2	564.0	41.2	12.0	162.4	47.5	303.	0.97	28.51
0.040	357.5	327.0	39.4	11.8	136.5	36.3	400.	1.09	28.38
0.041	363.5	340.0	40.1	12.0	145.7	33.7	357.	1.15	25.66
0.041	376.4	213.0	33.2	12.0	170.2	23.7	400.	1.36	20.96
0.041	374.2	224.0	33.5	11.5	165.0	23.9	385.	1.36	20.61
0.041	382.4	216.0	35.5	11.6	181.8	21.4	357.	1.42	19.63
0.044	347.6	222.0	36.8	11.8	114.8	29.4	476.	1.21	26.98

TABLE 1

q1	h1(Btu/lb)	Kw	eff	p2(psia)	p1(psia)	lbs/s	lbs/Kwh	Nd	Ns
0.045	377.7	108.0	25.4	11.8	166.2	15.0	500.	1.72	16.19
0.045	382.7	214.0	33.9	11.4	176.4	22.0	370.	1.39	19.90
0.045	377.1	221.0	33.5	11.5	164.0	23.6	385.	1.36	20.63
0.045	355.9	321.0	42.2	11.9	125.3	33.0	370.	1.16	26.70
0.045	359.2	339.0	41.9	12.0	129.6	33.5	357.	1.15	26.18
0.047	383.0	214.0	33.0	11.7	173.8	22.0	370.	1.40	19.74
0.047	347.6	223.0	36.7	11.5	110.8	29.5	476.	1.21	27.09
0.047	376.1	215.0	33.5	11.9	162.7	23.0	385.	1.38	20.27
0.049	383.1	215.0	33.1	11.6	171.8	22.2	370.	1.40	19.48
0.049	380.2	215.0	32.7	11.6	164.9	23.0	385.	1.38	20.07
0.049	362.8	342.0	40.9	12.0	132.3	33.9	357.	1.14	26.10
0.049	382.9	215.0	33.7	11.6	168.9	22.1	370.	1.40	19.71
0.049	380.3	213.0	33.0	11.7	163.7	22.8	385.	1.38	20.10
0.050	380.6	214.0	33.3	11.8	163.7	22.9	385.	1.38	20.29
0.050	348.8	279.0	42.6	12.2	108.7	31.0	400.	1.19	27.02
0.050	381.1	215.0	35.0	11.5	164.5	22.1	370.	1.39	20.24
0.050	349.3	279.0	42.4	12.2	109.3	31.0	400.	1.19	26.96
0.050	385.3	214.0	32.5	11.7	172.6	22.0	370.	1.41	19.18
0.050	359.5	335.0	44.3	12.0	124.7	32.1	345.	1.17	26.07
0.052	380.9	221.0	33.8	11.6	160.7	22.7	370.	1.39	19.93
0.052	380.4	212.0	33.2	11.6	158.9	22.6	385.	1.38	20.19
0.053	380.3	213.0	32.7	11.7	157.4	23.7	400.	1.34	21.01
0.053	384.5	216.0	33.0	11.6	165.0	22.2	370.	1.40	19.50
0.054	388.1	612.0	41.0	13.3	170.5	64.4	286.	0.85	31.61
0.056	381.9	213.0	33.6	11.4	156.0	21.9	370.	1.40	19.67
0.056	383.1	109.0	25.0	11.8	157.5	15.1	500.	1.70	16.29
0.056	382.4	216.0	33.9	11.7	155.8	22.2	370.	1.40	19.80
0.059	380.9	101.0	24.9	11.5	148.4	14.0	500.	1.76	15.62
0.060	381.9	107.0	26.5	11.8	149.3	14.2	476.	1.75	15.97
0.062	386.0	214.0	32.9	11.6	153.8	22.0	370.	1.40	19.44
0.062	386.2	218.0	33.6	11.5	153.3	21.6	357.	1.42	19.18
0.068	383.2	107.0	24.1	11.9	138.5	15.6	526.	1.66	16.74
0.068	380.8	102.0	25.8	11.8	133.8	14.2	500.	1.75	16.07

TABLE 1

q1	h1(Btu/lb)	kw	eff	p2(psia)	p1(psia)	lbs/s	lbs/Kwh	Nd	Ns
0.069	383.1	108.0	24.5	11.9	136.9	15.8	526.	1.65	17.04
0.071	380.6	108.0	27.2	11.9	128.7	15.0	500.	1.67	17.23
0.081	379.7	556.0	48.1	13.0	113.5	46.8	303.	0.94	31.63
0.082	404.2	380.0	40.6	12.1	155.3	27.8	263.	1.25	20.38
0.082	379.9	552.0	47.5	12.7	112.3	46.5	303.	0.95	31.35
0.095	404.9	474.0	45.2	12.2	135.3	31.3	238.	1.18	21.78
0.095	383.9	356.0	45.9	12.2	101.0	29.1	294.	1.20	23.96
0.095	405.2	478.0	45.2	12.2	134.7	32.4	244.	1.15	22.60
0.095	417.1	657.0	44.2	12.4	156.6	42.4	222.	1.02	24.12
0.097	417.0	690.0	44.0	12.3	155.0	42.6	222.	1.01	24.11
0.097	385.0	361.0	46.2	12.2	99.8	28.7	286.	1.21	23.42
0.099	457.5	589.0	35.1	12.3	252.3	31.5	192.	1.19	17.79
0.097	458.0	585.0	38.4	12.1	255.1	30.8	189.	1.20	17.50
0.100	458.5	537.0	38.3	12.2	252.9	30.8	189.	1.20	17.45
0.100	458.7	539.0	38.4	12.2	254.2	30.9	189.	1.20	17.52
0.100	458.5	587.0	38.5	12.2	252.0	30.8	189.	1.20	17.52
0.100	458.9	590.0	38.0	12.3	254.0	31.5	192.	1.19	17.82
0.101	458.9	591.0	38.5	12.2	251.9	31.0	189.	1.20	17.60
0.103	387.3	280.0	44.1	12.2	96.2	23.6	303.	1.32	21.58
0.107	454.6	591.0	38.0	12.1	256.4	30.4	185.	1.21	17.19
0.135	454.4	803.0	48.7	12.7	163.0	39.8	179.	1.01	22.86
0.135	454.4	803.0	48.7	12.7	163.0	39.8	179.	1.01	22.86
0.140	457.4	803.0	49.0	12.7	162.6	39.1	175.	1.01	22.58
0.145	455.7	536.0	49.2	12.8	149.4	42.2	182.	0.97	24.13
0.147	459.9	723.0	42.8	10.8	155.1	36.8	182.	1.02	21.27
0.147	474.2	550.0	44.0	11.7	185.7	25.5	167.	1.27	16.68
0.149	425.1	360.0	47.1	12.1	92.6	23.3	233.	1.29	19.99
0.149	423.4	279.0	44.4	12.1	89.1	19.4	250.	1.42	18.37
0.150	455.1	576.0	45.6	12.2	139.3	28.6	179.	1.20	18.80
0.151	456.3	573.0	45.3	12.1	140.3	28.4	179.	1.20	18.72
0.154	429.9	357.0	47.3	12.2	91.9	22.5	227.	1.31	19.56
0.160	444.1	530.0	52.7	12.2	104.7	28.3	192.	1.16	21.53
0.167	444.4	382.0	45.3	12.1	95.9	23.1	217.	1.29	19.02
0.169	444.3	382.0	45.3	12.2	95.4	23.1	217.	1.29	18.99

TABLE I

q1	h1(3tu/lb)	Kw	eff	p2(psia)	p1(psia)	lbs/s	lbs/Kwh	vd	Ns
0.168	444.8	382.0	45.4	12.1	95.2	23.1	217.	1.29	19.07
0.174	494.4	1059.0	47.5	12.9	179.3	43.9	149.	0.95	21.82
0.195	492.0	643.0	45.8	12.2	136.0	27.9	156.	1.19	17.59
0.196	492.9	643.0	46.0	12.2	135.8	27.9	156.	1.18	17.68
0.195	489.3	476.0	45.7	12.1	128.5	21.3	161.	1.35	15.70
0.198	456.1	278.0	44.3	12.1	87.7	16.1	208.	1.51	15.73
0.199	466.6	279.0	44.3	12.1	87.5	16.1	208.	1.51	15.77
0.200	492.0	474.0	45.9	12.1	127.6	20.9	159.	1.36	15.47
0.225	514.5	337.0	46.6	12.1	122.7	13.8	147.	1.65	12.41
0.234	545.3	543.0	50.2	12.1	179.4	17.3	115.	1.48	12.68
0.244	505.7	277.0	44.4	12.1	84.7	14.0	182.	1.57	14.11
0.245	506.7	277.0	44.5	12.1	84.3	14.0	182.	1.57	14.16
0.250	582.7	584.0	37.2	11.9	257.1	19.5	120.	1.44	11.51
0.250	582.8	587.0	37.2	11.9	254.5	19.6	120.	1.43	11.55
0.252	584.7	587.0	37.6	12.0	258.3	19.2	118.	1.45	11.30
0.254	586.1	585.0	37.3	11.9	258.2	19.1	118.	1.46	11.24
0.257	586.8	553.0	46.8	12.3	189.0	17.3	112.	1.46	12.10
0.292	559.9	538.0	55.7	12.3	103.6	17.8	119.	1.36	14.94
0.298	585.9	847.0	53.4	14.0	144.3	25.9	110.	1.15	16.40
0.303	589.4	847.0	51.7	13.3	144.2	25.6	109.	1.16	15.91
0.417	685.7	338.0	38.6	12.1	136.0	9.9	105.	1.83	8.60
0.422	686.3	340.0	38.0	12.1	126.8	10.4	110.	1.77	9.02
0.444	706.7	344.0	39.1	12.1	131.4	9.7	101.	1.83	8.50
0.623	856.2	333.0	40.2	12.1	110.4	7.4	80.	1.94	7.24
0.524	856.1	330.0	40.4	12.1	108.0	7.3	80.	1.94	7.23
0.525	867.1	341.0	39.2	12.1	136.4	7.0	74.	2.04	6.52
0.770	990.3	342.0	41.2	12.1	128.7	5.7	60.	2.17	5.69
0.967	1191.2	579.0	33.5	11.8	242.5	7.5	47.	1.95	5.01
0.989	1191.1	579.0	35.1	11.7	217.8	7.4	46.	1.93	5.16
0.993	1190.9	579.0	41.3	11.8	140.7	7.3	45.	1.85	5.79

TABLE 2

f(Kw)	f(pr)	f(q)	co	cop	coq	coKw	pr	Kw	q1
38.2	1.0	1.1	1.0	1.2	1.0	39.9	7.9	382.0	0.168
45.9	1.0	1.0	1.0	1.0	1.0	46.4	13.9	1059.0	0.174
43.5	1.0	1.1	1.0	1.0	1.0	42.6	11.1	643.0	0.195
43.5	1.0	1.1	1.0	1.1	1.0	42.5	11.1	643.0	0.196
41.1	1.0	1.1	1.0	1.1	1.0	42.1	10.5	475.0	0.196
34.4	1.0	1.1	1.1	1.3	1.1	38.5	7.2	278.0	0.198
34.4	1.0	1.1	1.1	1.3	1.1	38.5	7.2	279.0	0.199
41.1	1.0	1.1	1.0	1.1	1.0	42.2	10.5	474.0	0.200
35.7	1.0	1.1	1.2	1.3	1.2	42.6	10.1	337.0	0.228
42.7	1.0	1.0	1.2	1.2	1.2	50.0	14.8	543.0	0.234
34.3	1.0	1.2	1.1	1.3	1.1	38.5	7.0	277.0	0.244
34.3	1.0	1.2	1.1	1.3	1.1	38.5	7.0	277.0	0.246
43.1	1.0	0.9	1.0	0.9	1.0	42.5	21.6	584.0	0.250
43.1	1.0	0.9	1.0	0.9	1.0	42.3	21.4	587.0	0.250
43.1	1.0	0.9	1.0	0.9	1.0	42.9	21.5	587.0	0.252
43.1	1.0	0.9	1.0	0.9	1.0	42.7	21.7	585.0	0.254
42.3	1.0	1.0	1.1	1.1	1.1	47.1	15.4	553.0	0.257
42.7	1.0	1.1	1.2	1.3	1.2	50.3	8.4	538.0	0.292
45.4	1.0	1.1	1.1	1.2	1.1	49.0	10.3	847.0	0.298
45.4	1.0	1.1	1.1	1.1	1.1	47.8	10.8	847.0	0.303
36.7	1.0	1.1	1.0	1.0	1.0	35.8	11.2	333.0	0.417
36.3	1.0	1.1	0.9	1.0	1.0	34.8	10.5	340.0	0.422
35.9	1.0	1.1	1.0	1.1	1.0	36.0	10.9	344.0	0.444
35.5	1.0	1.1	1.0	1.1	1.0	35.9	9.1	333.0	0.623
35.4	1.0	1.1	1.0	1.1	1.0	35.9	8.9	330.0	0.624
35.3	1.0	1.1	1.0	1.1	1.0	36.3	11.3	341.0	0.626
35.3	1.0	1.1	1.0	1.1	1.0	38.3	10.6	342.0	0.770
43.0	0.9	0.9	0.9	0.6	0.9	40.5	20.6	579.0	0.987
43.0	0.9	0.9	0.9	0.9	0.9	40.8	18.5	579.0	0.989
43.0	0.9	1.1	1.0	1.0	0.9	42.5	11.9	579.0	0.998

TABLE 2

f(Kw)	t(pr)	f(q)	co	cop	coq	cokw	pr	Kw	ql
24.0	1.0	1.1	0.9	1.0	1.0	22.7	11.5	103.0	0.069
24.0	1.0	1.1	1.0	1.1	1.1	24.9	10.8	103.0	0.071
42.8	1.0	1.1	1.0	1.1	1.0	42.5	8.7	555.0	0.081
33.1	1.0	1.0	1.0	1.1	1.0	38.6	12.8	380.0	0.082
42.8	1.0	1.1	1.0	1.1	1.0	42.1	8.8	552.0	0.082
41.1	1.0	1.1	1.0	1.1	1.0	41.7	11.1	474.0	0.095
37.3	1.0	1.1	1.1	1.2	1.1	40.3	8.3	355.0	0.095
41.2	1.0	1.1	1.0	1.1	1.0	41.6	11.0	473.0	0.096
44.0	1.0	1.0	1.0	1.0	1.0	41.9	12.6	687.0	0.096
44.1	1.0	1.0	0.9	1.0	1.0	41.7	12.6	690.0	0.097
37.5	1.0	1.1	1.1	1.2	1.1	40.5	8.2	361.0	0.097
43.1	1.0	0.9	1.0	0.9	1.0	42.2	20.5	589.0	0.099
43.1	1.0	0.9	1.0	0.9	1.0	43.0	21.1	588.0	0.099
43.1	1.0	0.9	1.0	0.9	1.0	42.5	20.7	567.0	0.100
43.1	1.0	0.9	1.0	0.9	1.0	42.5	20.8	589.0	0.100
43.1	1.0	0.9	1.0	0.9	1.0	42.5	20.7	587.0	0.100
43.1	1.0	0.9	1.0	0.9	1.0	42.2	20.7	590.0	0.100
43.1	1.0	0.9	1.0	0.9	1.0	42.8	20.6	591.0	0.101
34.5	1.0	1.1	1.1	1.3	1.1	38.5	7.9	280.0	0.103
43.1	1.0	0.9	1.0	0.9	1.0	42.7	21.2	591.0	0.107
45.1	1.0	1.0	1.0	1.1	1.0	46.5	12.8	803.0	0.136
45.1	1.0	1.0	1.0	1.1	1.0	46.5	12.8	803.0	0.136
45.1	1.0	1.0	1.0	1.1	1.0	46.8	12.8	803.0	0.140
45.3	1.0	1.1	1.0	1.1	1.0	46.1	11.7	836.0	0.145
44.4	1.0	1.0	0.9	1.0	1.0	42.1	14.4	723.0	0.147
42.8	1.0	1.0	1.0	1.0	1.0	44.5	15.9	550.0	0.147
37.5	1.0	1.1	1.1	1.3	1.1	41.1	7.7	360.0	0.148
34.4	1.0	1.1	1.1	1.3	1.1	38.6	7.4	279.0	0.149
43.0	1.0	1.1	1.0	1.1	1.0	43.4	11.4	575.0	0.150
43.0	1.0	1.1	1.0	1.1	1.0	43.3	11.6	573.0	0.151
37.4	1.0	1.1	1.1	1.3	1.1	41.3	7.5	357.0	0.154
42.7	1.0	1.1	1.1	1.2	1.1	46.8	8.6	530.0	0.160
33.2	1.0	1.1	1.0	1.2	1.0	39.8	7.9	382.0	0.167
33.2	1.0	1.1	1.0	1.2	1.0	39.7	7.8	382.0	0.168

TABLE 2

f(Kw)	f(pr)	f(q)	co	cop	coq	COKW	pr	Kw	ql
24.0	1.0	1.0	1.0	1.0	1.0	24.6	14.1	109.0	0.045
31.4	1.0	1.0	1.1	1.1	1.1	33.6	15.5	214.0	0.045
31.8	1.0	1.0	1.0	1.0	1.0	32.5	14.3	221.0	0.045
35.1	1.0	1.1	1.1	1.2	1.1	38.3	10.5	321.0	0.046
35.7	1.0	1.1	1.0	1.1	1.1	38.2	10.8	338.0	0.046
31.4	1.0	1.0	1.1	1.1	1.1	33.3	14.9	214.0	0.047
31.9	1.0	1.1	1.0	1.1	1.0	32.7	9.6	223.0	0.047
31.5	1.0	1.0	1.0	1.0	1.0	32.1	13.7	215.0	0.047
31.5	1.0	1.0	1.0	1.0	1.0	32.5	14.3	215.0	0.048
31.5	1.0	1.0	1.0	1.0	1.0	31.7	14.2	215.0	0.048
35.3	1.0	1.1	1.0	1.1	1.0	37.4	11.0	342.0	0.049
31.5	1.0	1.0	1.0	1.1	1.1	32.9	14.6	215.0	0.049
31.4	1.0	1.0	1.0	1.0	1.0	31.9	14.0	213.0	0.049
31.4	1.0	1.0	1.0	1.0	1.0	32.1	13.9	214.0	0.050
34.4	1.0	1.1	1.1	1.2	1.1	37.6	8.9	279.0	0.050
31.5	1.0	1.0	1.1	1.1	1.1	33.9	14.2	215.0	0.050
34.4	1.0	1.1	1.1	1.2	1.1	37.4	9.0	279.0	0.050
31.4	1.0	1.0	1.0	1.0	1.0	31.8	14.8	214.0	0.050
35.5	1.0	1.1	1.1	1.2	1.1	40.1	10.4	335.0	0.050
31.3	1.0	1.0	1.0	1.0	1.0	32.6	13.9	221.0	0.052
31.3	1.0	1.0	1.0	1.0	1.0	31.9	13.7	212.0	0.052
31.4	1.0	1.0	1.0	1.0	1.0	31.3	13.5	213.0	0.053
31.5	1.0	1.0	1.0	1.0	1.0	32.0	14.2	215.0	0.053
45.1	1.0	1.0	0.9	0.9	0.9	38.8	12.8	812.0	0.054
31.4	1.0	1.0	1.0	1.1	1.0	32.3	13.7	213.0	0.056
24.1	1.0	1.0	1.0	1.0	1.0	23.9	13.3	109.0	0.056
31.5	1.0	1.0	1.0	1.1	1.0	32.4	13.3	215.0	0.056
23.2	1.0	1.0	1.0	1.1	1.0	23.6	12.9	101.0	0.059
23.9	1.0	1.0	1.1	1.1	1.1	25.3	12.7	107.0	0.060
31.4	1.0	1.0	1.0	1.0	1.0	31.4	13.3	214.0	0.062
31.5	1.0	1.0	1.0	1.1	1.0	32.3	13.3	213.0	0.062
23.9	1.0	1.1	0.9	1.0	0.9	22.4	11.6	107.0	0.068
23.4	1.0	1.1	1.0	1.1	1.0	23.8	11.3	102.0	0.068

TABLE 2

f(kw)	f(pr)	f(q)	co	cop	coq	cokw	pr	kw	q1
35.3	1.0	1.0	1.0	1.0	1.0	36.7	16.7	323.0	0.005
43.8	1.0	0.9	0.9	0.8	1.0	41.0	20.9	657.0	0.008
43.8	1.0	0.9	1.0	0.8	1.0	42.0	21.6	661.0	0.008
29.5	1.0	1.1	0.9	1.0	0.9	26.2	9.2	181.0	0.008
43.8	1.0	0.9	0.9	0.8	1.0	40.6	19.8	657.0	0.008
41.5	1.0	0.9	1.0	0.9	1.0	40.1	20.2	489.0	0.008
32.2	1.0	1.1	0.9	1.0	0.9	29.0	10.1	230.0	0.010
40.0	1.0	0.9	1.0	0.9	1.1	41.1	19.9	433.0	0.012
38.5	1.0	1.1	0.9	1.0	0.9	34.8	9.1	394.0	0.013
39.4	1.0	1.0	1.0	0.9	1.0	38.1	16.1	420.0	0.014
40.0	1.0	0.9	1.0	0.9	1.0	40.9	19.7	438.0	0.014
40.0	1.0	0.9	1.0	0.9	1.0	40.7	19.5	433.0	0.014
38.5	1.0	1.1	0.9	1.0	0.9	34.5	9.0	394.0	0.015
39.9	1.0	0.9	1.0	0.9	1.0	40.5	19.5	436.0	0.015
38.7	1.0	0.9	1.0	0.9	1.0	39.4	18.9	393.0	0.015
40.0	1.0	0.9	1.0	0.9	1.0	39.8	19.2	439.0	0.016
25.3	1.0	1.1	0.9	1.0	0.9	22.1	9.2	122.0	0.016
39.8	1.0	0.9	1.0	0.9	1.0	38.2	18.8	433.0	0.019
33.6	1.0	1.1	0.9	0.9	0.9	33.8	10.9	394.0	0.022
33.5	1.0	1.1	0.9	1.0	0.9	35.7	8.8	392.0	0.025
35.7	1.0	1.1	0.9	1.0	0.9	33.8	8.7	345.0	0.026
38.5	1.0	1.1	0.9	1.0	0.9	35.4	8.6	392.0	0.027
39.5	1.0	1.0	1.0	1.0	1.0	37.8	13.5	425.0	0.031
32.0	1.0	1.0	1.0	1.1	1.0	32.6	13.0	225.0	0.033
42.7	1.0	1.0	1.0	1.0	1.0	41.3	15.0	563.0	0.035
31.7	1.0	1.0	1.0	1.0	1.0	32.3	14.7	220.0	0.036
42.9	1.0	1.0	0.9	0.9	1.0	40.6	15.2	564.0	0.039
35.3	1.0	1.1	1.0	1.1	1.0	36.3	11.6	327.0	0.040
35.8	1.0	1.1	1.0	1.1	1.0	37.4	12.1	340.0	0.041
31.4	1.0	1.0	1.0	1.0	1.0	32.1	14.2	213.0	0.041
31.9	1.0	1.0	1.0	1.0	1.0	32.5	14.3	224.0	0.041
31.5	1.0	1.0	1.1	1.1	1.1	35.3	15.7	215.0	0.041
31.8	1.0	1.1	1.0	1.1	1.1	32.9	9.7	222.0	0.044

RUN#	DATE	COMMENT	INLET PRESS	EXH PRESS	PRESS RATIO	SPEED	FLOW RATE	INLET ENTHL	EFF	POWER	FLOW RATIO	SPEC SPEED	SPEC SIZE	LEAK RATE	CHOKE #	INLET QUAL	EXIT QUAL
524	4/13/83	11	88.4	13.0	6.8	4500.	0.461	1183.2	35.6	21.0	0.00	3.54	2.20	0.300	1.00	0.998	0.985
525	4/13/83	11	89.6	13.0	6.9	6004.	0.461	1183.0	35.4	24.0	0.00	3.52	2.21	0.298	1.01	0.998	0.985
526	4/13/83	11	88.4	13.0	6.8	7484.	0.497	1182.4	38.3	27.9	0.00	4.59	2.12	0.297	1.00	0.997	0.980
527	4/13/83	11	87.8	13.0	6.7	8989.	0.539	1182.4	39.6	31.1	0.00	5.75	2.03	0.300	0.99	0.997	0.979
528	4/13/83	11	103.0	13.0	7.9	8995.	0.625	1182.1	41.0	40.3	0.00	5.81	1.94	0.345	1.16	0.994	0.972
529	4/13/83	11	104.5	13.0	8.0	7507.	0.582	1182.6	38.9	35.9	0.00	4.66	2.01	0.345	1.17	0.994	0.975
530	4/13/83	11	104.5	13.0	8.0	6003.	0.531	1183.0	35.7	30.1	0.00	3.56	2.11	0.342	1.17	0.994	0.981
531	4/13/83	11	104.5	13.3	7.9	4497.	0.478	1183.0	31.0	23.3	0.00	2.52	2.23	0.337	1.15	0.994	0.988
532	4/13/83	11	121.2	13.1	9.2	4520.	0.552	1182.7	30.6	28.5	0.00	2.58	2.12	0.387	1.35	0.991	0.985
533	4/13/83	11	119.6	13.0	9.2	5997.	0.602	1182.6	35.0	25.5	0.00	3.60	2.02	0.387	1.34	0.991	0.978
534	4/13/83	11	119.6	13.0	9.2	7494.	0.659	1182.4	38.0	42.1	0.00	4.70	1.93	0.389	1.34	0.991	0.973
535	4/13/83	11	120.1	13.0	9.2	9011.	0.703	1174.7	39.4	46.3	0.00	5.85	1.87	0.375	1.35	0.982	0.963
536	4/20/83	11	120.4	13.0	9.2	6007.	1.023	747.5	38.4	35.7	1.00	5.64	1.75	0.591	1.58	0.495	0.555
537	4/20/83	11	118.0	13.0	9.1	4494.	0.901	747.6	33.5	27.3	0.99	3.98	1.86	0.584	1.54	0.496	0.559
540	4/25/83	11	87.1	13.0	6.7	10502.	0.560	1183.0	37.1	30.2	0.00	6.87	1.99	0.283	0.98	0.998	0.983
541	4/25/83	11	103.5	13.0	8.0	10507.	0.663	1183.2	41.3	43.4	0.00	6.98	1.88	0.335	1.17	0.995	0.972
542	4/25/83	11	119.6	13.3	9.0	10524.	0.767	1183.7	42.9	55.0	0.00	7.10	1.80	0.389	1.31	0.992	0.966

TABLE 3