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Final Report

Richard A. McKay

June 1, 1984

Prepared for
U.S. Department of Energy
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Prepared by the Jet Propulsion Laboratory, California Institute of Technology, for the U.S. Department of Energy through an agreement with the National Aeronautics and Space Administration. (NASA Task RE-152, Amendment 226; DOE Interagency Agreement DE-AI03-79ET37116)

ABSTRACT

A 1-MW wellhead generator was tested in 1980, 1981, and 1982 by Mexico, Italy, and New Zealand at Cerro Prieto, Cesano, and Broadlands, respectively. These tests were performed with the participation of the U.S. Department of Energy, the Hydrothermal Power Co., Ltd., and the Jet Propulsion Laboratory, under the auspices of the International Energy Agency. The total flow helical screw expander portable power plant, Model 76-1, had been built for the U.S. Government and field-tested in Utah, USA, in 1978 and 1979. The expander had oversized internal clearances designed for self-cleaning operation on fluids that deposit adherent scale normally detrimental to the utilization of liquid-dominated fields. Conditions with which the expander was tested included inlet pressures of 64 to 220 psia, inlet qualities of 0% to 100%, exhaust pressures of 3.1 to 40 psia, electrical loads of idle and 110 to 933 kW, electrical frequencies of 50 and 60 Hz, male rotor speeds of 2500 to 4000 rpm, and fluid characteristics to 310,000 ppm total dissolved solids and noncondensables to 38 wt % of the vapor. Some testing was done on-grid. Typical expander isentropic efficiency was 40% to 50% with the clearances not closed, and 5 percentage points or more higher with the clearances partly closed. The expander efficiency increased approximately logarithmically with shaft power for most operations, while inlet quality, speed, and pressure ratio across the machine had only small effects. These findings are all in agreement with the Utah test results. Condensing tests produced lower machine efficiencies but also lower flowrates per kW of electricity produced. Based on operating results and cost/benefit analyses in comparison with 1-MW turbine generators, Mexico and Italy rated the screw expander power plant as suitable for noncondensing service in some liquid-dominated fields, although the unit tested needs shaft seal repair before it is returned to service. Improvements of the shaft seal flush water system and the speed control system are important, and closing of the rotor clearances, either through manufacturing changes or operating changes, is necessary for best performance. Lower prices through mass production would broaden the application.

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SUMMARY

A. GENERAL

A 1-MW wellhead generator was tested in Mexico, Italy and New Zealand as part of the International Energy Agency (IEA) programme of research, development and demonstration on geothermal equipment. The wellhead generator used in the tests was a total flow helical screw expander (HSE) portable power plant, Model 76-1, which had been built for the U.S. Government and field-tested in Utah, USA, in 1978 and 1979. The HSE was designed with oversized internal clearances for the specific purpose of operating on mineralized geothermal fluids that deposit adherent scale normally detrimental to utilization. The test activities with the HSE in Mexico were conducted at Cerro Prieto by the Comision Federal de Electricidad (CFE) using well M-11 from December 1979 through April 1981. In Italy the tests were conducted by the Ente Nazionale per l'Energia Elettrica (ENEL) at Cesano 1 well from July 1981 to June 1982. Those tests in New Zealand were performed by the Ministry of Works and Development (MWD) at the Broadlands field with well BR 19 from September 1982 to June 1983. The U.S. Department of Energy (DOE) participated in the tests with the assistance of the Hydrothermal Power Co., Ltd. (HPC) (manufacturer of the power plant), and the Jet Propulsion Laboratory (JPL). The HSE power plant was made available by the U.S. Department of Energy for the tests in these other countries after it was determined that small power plants in the HSE size range most likely to be built could have international utility. A total test summary, including the testing in the USA, is listed in Table S-1.

Table S-1. HSE Power Plant Total Test Summary

Location and	Year	Power Production Time h	Power Production Time Σh	Generator Output kWh	Generator Output ΣkWh
California, USA	1977*	5	5	nil	nil
Utah, USA	1978	337	342	85,170	85,170
Utah, USA	1979	100	442	27,540	112,710
Mexico	1980	1,064	1,506	854,830	967,530
Mexico	1981	37	1,543	10,110	997,640
Italy	1981	23	1,566	4,740	982,380
Italy	1982	98	1,664	21,720	1,004,100
New Zealand	1982	102	1,766	36,580	1,040,680
New Zealand	1983	1,633	3,399	1,330,250	2,370,930

* Acceptance test using compressed air at factory.

PRECEDING

The work in Mexico, Italy and New Zealand conformed to the IEA programme objectives to accelerate the development of geothermal resources through early introduction of advanced geothermal energy conversion technology. The test objectives for each country were to assess the performance and reliability of the wellhead generator and to assess the applicability of the power plant to the test site or an appropriate alternative site within the country. The assessment of applicability was based on costs and benefits of the HSE power plant in comparison with a turbine generator set of the same 1-MW size, both i noncondensing operation. The HSE power plant cost that was used was for a one-of-a-kind machine and was not the cost of a production model.

The performance testing in the IEA programme encompassed a wide range of operating conditions in order to map the operational characteristics of the HSE. The test parameters that were varied were the inlet pressure inlet steam quality, exhaust pressure, electrical load, electrical frequency, male rotor speed, and geothermal fluid properties, all in various combinations. The ranges were as follows:

Inlet pressure (psia)	64 to 220
Inlet quality (%)	0 to 100
Exhaust pressure (psia)	3.1 to 40
Electrical load (kW)	idle and 110 to 933
Electrical frequency (Hz)	50 and 60
Male rotor speed (rpm)	2500, 3000, 3333 and 4000
Total dissolved solids (ppm)	low to 310,000
Noncondensables (wt % of vapor)	low to 38.0

The isentropic efficiency of the helical screw expander was taken as the primary measure of performance of the power plant. This efficiency compares the actual expander with an ideal expander operating over the same pressure interval and is commonly known as machine efficiency. Efficiency values in the range of 40% to 55% were demonstrated as typical for the machine as tested. The desired closing of the oversized internal clearances within the HSE was not achieved during these tests and so the performance of the HSE with the clearances reduced to within normal limits for this type of machine was not determined at any site. In Italy, despite very rapid scale growth, the expected tests with small clearances were not possible because the scale did not remain on the rotors. Machine efficiency was found to be around 45%, well below the 65% to 68% limit predicted by ENEL for operation with small clearances using a theoretical model of machine performance based on an analysis of the Utah and Mexico test data. However, without tests with small clearances, the performance available with this HSE remains unknown.

Endurance tests made to assess the reliability contributed to the determination of performance. In New Zealand the growth of a very thin layer of scale on the rotors during 1632 hours of endurance testing resulted in a 3.5 percentage-point improvement in the efficiency. At the end of the test the efficiency was 46.5% and evidently still increasing. A greater improvement was determined during the endurance test in Mexico but the amount of increase was uncertain. The corresponding amount of scale growth achieved to partly close the oversized clearances was also uncertain but small.

For many operating conditions the expander efficiency increased approximately logarithmically with shaft power. Inlet quality and the ratio of inlet to outlet pressure had a small influence on the efficiency. The optimum speed varied with shaft power, but again the influence was small in the range tested. Because of the number of parameters that influence the efficiency, correlation of the data was difficult. Therefore, for some purposes it was convenient to plot the efficiency of the HSE as a function of the most important variable, shaft power, and let the effect of the other variables appear as data scatter, although many of the measurements that appear to be scattered in this treatment were actually quite reproducible. By this and similar methods of correlation, representative efficiencies were determined for each test site. With bare rotors and oversized clearances for noncondensing operation, these efficiencies ranged from 40% in New Zealand to 48% in Mexico, for half load or more. Corresponding determinations yielded 45% for the HSE operation in Italy (and 48% for the earlier test operation in the USA). The lower efficiency demonstrated in New Zealand relative to the other three sites has not been explained.

Some limited condensing testing was performed in Mexico. In all cases the HSE efficiency decreased with decreasing back pressure but so also did the flowrate per kW of electricity produced.

The effect of rotor speed on the machine efficiency was small for tests in Mexico and New Zealand.

All testing in Mexico, Italy and New Zealand used the low-pressure inlet trim in the speed control valve in the HSE. The resulting stable operating range of inlet pressure was limited to below about 200 psia because of limitations in the speed control system. These same limitations prevented idling at pressures above about 130 psia with this trim. These limits vary with inlet steam quality because they relate to the control of volumetric flowrate into the machine. The results demonstrated a need for further development of the speed control system to provide stable operation over the full range of load from idle to full load for all wellhead pressures.

The reliability of the HSE power plant was assessed during the performance and endurance testing. The shaft seals were of greatest concern, because they were newly designed replacements used only for the 100 hours of Utah testing immediately preceding the beginning of the International Test and Demonstration Programme. No seal problems occurred during the 1100 hours of operation in Mexico, but seal damage occurred in Italy and in New Zealand. In Italy the damage was caused during the first 18 hours of operation by impacts resulting from scale that had been rapidly deposited within the machine. A seal design modification after about 24 hours of operation corrected the breakage problem. Intensive examination of the broken seals by several parties indicated no signs of wear resulting from the cumulative 1224 hours of seal operation.

In New Zealand a seal assembly evidencing a materials flaw was replaced (after 98 hours of operation in Italy and 102 hours in New Zealand). The seals within the assembly were also found to be abraded, apparently by particulates found in the assembly. During the following 1632 hours of endurance testing, progressively increasing oil leakage beyond the design specifications occurred, resulting in premature termination of testing. The cause of the leakage was not actually determined, but it may have been caused by abrasive wear by the particulates. Questions regarding seal wear or damage must be resolved before further use of the HSE is considered.

During replacement of the damaged shaft seals in Italy, passages for recapturing oil from the flush water were installed to make the HSE more reliable in case of wear or damage of the shaft seals. Suitable ancillary equipment for operating the recapture system was not available. Deficiencies in the available equipment resulted in maintenance and reliability problems with oil filters and with scavenger pumps for removing water from oil reservoirs.

The operation of the HSE power plant is no more complex than any other form of small turbine generating plant and satisfactory operation with once-daily inspection was demonstrated in New Zealand.

Cost/benefit analyses were performed by each country on the basis that the deliberately oversized internal clearance (to be closed by scale deposition) would not be closed during prolonged service. Machine efficiencies of 45% in Italy and New Zealand and 48% in Mexico were used. A new plant cost of $770,000 to $800,000 U.S. was used in the analyses, based on the assumption that such a plant could be purchased. The analyses showed that on these bases, the HSE power plant tested, Model 76-1, cannot compete with a conventional steam turbine, considering both cost and performance. For some applications the HSE can compete on the basis of performance. For example, at a 48% efficiency the HSE performance is advantageous for hot-water reservoirs with temperatures up to 275°C in Mexico. In Italy the HSE can compete on the basis of both cost and performance for certain applications, mostly because of its versatility and higher overall efficiency. The analysis for Mexico showed that if the HSE efficiency were to rise to 55% as was demonstrated, it would be preferred to a turbine for all applications on the basis of performance, but not on the basis of cost. The estimation of the performance at which the HSE could compete despite a higher capital cost was outside the scope of these analyses.

B. CONCLUSIONS

The HSE power plant, Model 76-1:

- is suitable for electric power production in some liquid-dominated geothermal fields, although the unit tested needs repair of damaged shaft seals before it is returned to service.
- can compete with a steam turbine on the basis of performance for some applications.
- cannot compete with a mass-produced steam turbine on the basis of the stated capital cost for a single HSE machine performing as tested.
- is rugged and is not damaged by typical geothermal process upsets.
- can operate on an unattended basis with periodic inspections and maintenance.

- can be put on and off grid manually with simple equipment.

- is not suitable for continuous operation on a rapidly scaling brine such as from Cesano 1, Italy.

The HSE Model 76-1 machine efficiency:

- is in the range of 45% to 50% with bare rotors for a wide range of load, inlet pressure and steam quality in noncondensing operation.

- increases with scale deposition within the machine, but the performance potential with the small internal clearances normal for a machine of this type has not been determined.

- increases with load but is fairly flat over the upper 75% of its load range.

- is insensitive to inlet fluid quality but diminishes at the extremes.

- is insensitive to rotor speed over the 2500-rpm to 4000-rpm range tested.

- decreases with increasing backpressure.

- decreases with reduced backpressure, but the energy produced per pound of fluid used increases with decreasing backpressure over the range tested.

The HSE Model 76-1:

- shaft seals have a demonstrated mode of operation in which no detectable wear is observed after 1224 hours of service, but long service life has not been demonstrated.

- shaft seal support system is not correctly sized and installed.

- speed control system is not adequate for all loads and all wellhead pressures in all combinations.

- internal clearances are excessive for use on fluids that do not deposit adherent scale on the rotors.

The IEA Test and Demonstration Programme tests confirmed the results of testing in Utah.

SECTION I

INTRODUCTION

This is the final report on a task to test and demonstrate a 1-MW geothermal wellhead generator in the field (the Task), carried out sequentially in Mexico, Italy and New Zealand (the Host Countries), with the participation of the U.S. Department of Energy (DOE) (the Operating Agent) and the assistance of the Hydrothermal Power Co., Ltd. (HPC) and the Jet Propulsion Laboratory (JPL). The Host Countries were represented by the Comision Federal de Electricidad (CFE), Mexico, Ente Nazionale per l'Energia Elettrica (ENEL), Italy, and the Ministry of Works and Development (MWD), New Zealand. The final report summarizes the work performed in the three countries and reported in interim status reports by CFE, Ref. A, ENEL, Ref. B, and MWD, Ref. C.

The Task was part of a cooperative program defined in an International Energy Agency Implementing Agreement for a Programme of Research, Development and Demonstration on Geothermal Equipment as described in Annex I: Test and Demonstration of A 1-MW Wellhead Generator. In the Annex, CFE, ENEL, MWD, and DOE were designated as Participants of the Task and the responsibilities of the Host Countries and the Operating Agent were assigned. Task management was vested in an Executive Committee consisting of one member from each country. The schedule of the Task as planned and as achieved is shown in Table 1-1.

The wellhead generator used in this Task was a transportable total flow helical screw expander power plant HPC Model 76-1, which had been designed and field-tested earlier for the U.S. Government in a project managed by JPL (Ref. 1). The expander was designed by HPC with oversized clearances for use only in liquid-dominated geothermal fields that produce fluids suitable for producing adherent scale deposits within the machine.

The power plant was made available to the Task by DOE, acting within the framework of the U.S. membership in the International Energy Agency and under the auspices of the Committee of Energy Research and Development of the Agency. The power plant was accompanied by test support equipment including a computer-equipped data system, an instrumentation and control van, and a transportable 1000-kW variable load bank, all of which had been integrated with the power plant into a test array designed for operation at a variety of geothermal field sites. All of this equipment is described in Ref. 1 and in manuals that were included with the equipment. Additional fabrication details of the power plant are described in Ref. 2. The results of the earlier work are summarized later in this section.

This final report includes (a) an assessment of the performance and reliability of the power plant under the differing geothermal conditions of the test sites, and (b) a cost/benefit analysis of the power plant relative to each site as required by the Implementing Agreement, Annex I, which assigned the responsibility for the final report to DOE. By direction of the Executive Committee, the final report is based on the interim status reports (Refs. A, B, and C) submitted by each of the three Host Countries. Much of the report is

Table 1-1. Programme Schedule: Plan, x; Actual, ●

Participant	Work to be Performed	1978	1979	1980	1981	1982	1983	1984
U.S. (Operating Agent)	Delivery of the Power Plant for Transport to Mexico		x ●					
	Development of the Test and Demonstration Programme	●●	xxx					
	Final Report				xxxx		●●●	●●●●●
Mexico (Host Country)	Site Selection and Site Preparation	●	● xxxx ●					
	Installation of the Power Plant		x ●	●●●				
	Test and Demonstration Programme		xxxx	xx ●●● ●●●●●●	●●			
	Delivery of the Power Plant for Transport to Italy			x	●		●●	
	Interim Status Report			xx	●●		●● ●●●	●
Italy (Host Country)	Site Selection and Site Preparation		xxxxx	x				
	Installation of the Power Plant			x	●●●			
	Test and Demonstration Programme			xx xxx	●●	●●●		
	Delivery of the Power Plant for Transport to New Zealand			x		●		
	Interim Status Report			xx		●●	●	
New Zealand (Host Country)	Site Selection and Site Preparation			xxxx				
	Installation of the Power Plant			x		●●		
	Test and Demonstration Programme			x	xxxxx	●●●	●●●●	
	Delivery of the Power Plant for Transport to United States				x		●	
	Interim Status Report				x x		●● ●	

presented in country sequence - Mexico, Italy, New Zealand - with the status reports and the Appendixes coded A, B, and C in the same sequence, as a convenience to the reader.

Some of the material in this report is repeated verbatim from the sources without quote marks. Figures and tables from the interim status reports were copied from the originals in most cases, except for the identification numbers. To the extent deemed necessary or appropriate by JPL, some information in this report is from the JPL report on the prior work (Ref. 1) or from the author's reports and notebooks and general information of the author compiled during this task or the prior work. In addition, information from HPC is included.

In the prior work (Ref. 1), th HSE power plant was tested in Utah in 1978 and 1979. An average machine efficiency of approximately 45% was demonstrated over a wide range of test conditions in noncondensing operation on single-phase and two-phase geothermal fluids. The efficiency was fairly flat above one-quarter load, although efficiencies as high as 54% were demonstrated. The test data characterize an expander having large internal clearances or leakage passages past the rotors which, contrary to plan, did not close with scale deposits during the testing. Analysis of the data showed that the expander efficiency is a strong function of load, a weak function of inlet steam quality and of pressure ratio across the expander, and independent of throttle position. Test conditions included inlet pressure ranging from 84 to 258 psia, inlet steam quality of 0% to 99%, linear throttle position from 7% to 100% open, output shaft load from idle to 1059 kW, with output shaft or male rotor speed of 3000 rpm. The exhaust pressure was atmospheric at about 12 psia except for a few tests performed at exhaust pressures of 27 to 30 psia. The need to improve the speed control system to accommodate small loads at high feed pressure or the sudden loss of large loads was identified. So also was the need to fabricate the HSE with smaller internal clearances for best efficiency with nonscaling brine. Other design changes for a replacement 5-MW unit originally planned were also identified and recommended.

A. TASK OBJECTIVES

The objectives of the Task were to:

(1) Accelerate the development of geothermal resources through early introduction of advanced geothermal energy conversion technology;

(2) Provide prospective users of geothermal energy experience in operating advanced technology geothermal equipment; and

(3) Develop a data base for a range of geothermal resource conditions of the power plant's performance and reliability in order to assess the cost/benefits in the application of the power plant.

In addition, each Host Country had its own specific test objectives. These are described in Section III.

B. TASK RESPONSIBILITIES

The main responsibilities of DOE as Operating Agent were to:

(1) Provide the operational power plant, including support equipment for the Task;

(2) Provide two Technical Specialists* from the prior work to advise on the installation and operation of the power plant during the test and demonstration programmes in each country;

(3) Perform major equipment repair;

(4) Prepare and distribute to Participants a final report on the Task; and

(5) Bear the costs of the above and of transporting the power plant and support equipment back to the United States at the end of the Task.

The main responsibilities of the other Participants were to:

(1) Provide a test site and programme plan acceptable to the Executive Committee;

(2) Make the necessary site-related preparations prior to the installation of the power plant;

(3) Be responsible for the installation and routine maintenance of the power plant;

(4) Be responsible for the test and demonstration programmes, including the electrical, instrumentation and computer work, and all data gathering;

(5) Report the data and its evaluation to other Participants, including an assessment on the costs and benefits in the application of the power plant;

(6) Prepare the power plant and the support equipment for shipment from the site; and

(7) Bear the costs of the above.

At the request of ENEL, and with the concurrence of the Executive Committee, the power plant and test support equipment were converted from 60 Hz to 50 Hz in preparation for the testing in Italy. The purpose was to allow testing with the power plant connected to the ENEL electrical grid. By agreement, the conversion was the responsibility of DOE and was carried out by HPC; the costs of the hardware for the conversion were shared by DOE and ENEL.

* R. McKay, JPL, author of this report, and R. Sprankle, HPC, designer of the power plant.

SECTION II

LIMITS AND LIMITATIONS

The assessment of the performance characteristics of the 1-MW helical screw expander wellhead generator and of the costs/benefits in its application were based on the testing of HSE Model 76-1. The test results were influenced significantly by the limits and limitations that were either implicit to or imposed on the equipment and tests. It is essential that these be understood in order to interpret the test results. This was to be an evaluation of an existing design and there were no provisions for modifications or improvements to the HSE.

A. DESIGN LIMITATIONS

The helical screw expander power plant used on this programme was HPC Model 76-1, which was designed in 1974-1975 specifically for use on scaling fluids from liquid-dominated geothermal resources. This machine was a twenty-fold scale-up of a 50-kW prototype developed in 1972-1973. Some changes or developments were identified as desirable during the 1978-1979 testing in Utah, but of these only the shaft seals modifications were made. Additional development work on the HSE power plant by the manufacturer was not included as part of the IEA Task because of budgetary and Task schedule limitations. Repairs were included, but only to the extent necessary to permit the test and demonstration to proceed with minimum delay. Notable design areas identified in Utah as needing change or development in order to broaden the application of the HSE were rotor clearances, the shaft seal system, and the speed control system. These impacted test considerations as follows:

1. Rotor Clearances

The rotor-to-rotor and rotor-to-case clearances in HSE Model 76-1 were made large, based on the experience of testing the 50-kW prototype and its forerunner on Wells M-7 and M-10 in Cerro Prieto, Mexico. Fluids from these wells had deposited adherent scale within the screw expanders which accumulated to close the leakage paths past the rotors. Good scale adhesion was not always immediate, depending on the initial surface conditions within the machines, but closure occurred in each case in about 24 hours of testing. The clearances for Model 76-1 were intended to be large enough that the scale deposits would serve as a cladding to protect the rotors and casing interior from possible corrosion and to protect the rotors from possible erosion in the inlet areas. Hard tips were provided on the rotor lobe crests to abrade or limit scale growth on the opposing surfaces so as to provide finished dimensions lapped to close tolerances, as occurred with the 50-kW prototype. The size of the initial clearances and the resulting leakage past the rotors in Model 76-1 were expected to preclude attractive machine efficiency for operation with any clean, nonscaling fluid. Valid testing of the machine for its as-designed performance potential was expected to be limited only to the use of fluids and test conditions that would result in adherent scale growth within the machine. The building of scale on the rotors was considered necessary to complete the fabrication of this model HSE. The importance of the scale is explained by the estimate that in certain positions of the rotors, the cross-sectional area of the leakage paths from the high-pressure pocket was calculated to be 25% to 30% of the pocket envelope (Ref. 1).

2. Shaft Seal System

The original shaft seal system used seal assemblies designed for protection from the geothermal fluids by oil leakage past them into the machine. The design failed in Utah in 1978 and was replaced in 1979 with a new design that used a fresh water barrier. The fresh water was injected into the new assemblies at controlled rates, with most of the water flowing toward the interior of the machine and to waste. It was known that some oil would migrate past the oil/water seal at a rate determined by the temperature and surface speed. The oil lost in this manner was initially expected to be acceptable. Under test it was soon discovered that some of the water migrated past the oil/water seal and into the oil. The water traveled with the oil to the oil console, where it settled to the bottom of the reservoir and could be tapped off. However, it is not desirable to have water in the oil, and better methods for removal than settling are available. The installation of a centrifuge in the return oil line to the reservoir was recommended during the Utah overhaul confirmation test in 1979 and was installed on the console in Mexico in 1980 in preparation for the testing there. The centrifuge was of suitable size for the intended job.

It was known from shop tests that the rate of oil migration past the oil/water seal into the flush water in each assembly was controlled predominantly by the oil temperature and surface speed of the seals. For operation at 3000-rpm male rotor speed and with normal oil temperatures, the oil loss was estimated to average about 1 gal. per seal assembly per day. The rate differs for each assembly since no two have the same speed and pressure distribution. Since it was known that oil would migrate into the water, it was recognized during design that the oil could be recovered by withdrawing the oil-laden water from each seal assembly through correctly located bleed passages; increasing the flow of flush water by an amount equal to the amount withdrawn would maintain the fresh water barrier. The oil could then be removed from the withdrawn water and the recovered oil and water recycled. This procedure would have required performing the difficult job of installing passages in the HSE housing in the field in Utah. This was not done to save time and money, and because it was recognized that the new seal design could be verified while operating with the predicted oil loss. This design limitation was considered acceptable.

In Italy, three seal assemblies were replaced because of breakage of some of the seal segments from mechanical shock caused by scale build-up within the machine. The replacement assemblies were provided with bleed passages for recovery of oil that migrates across certain seals into the flush water. Before installing the assemblies, corresponding bleed passages were drilled into the HSE housing to allow recovery of the oil. The centrifuge was not large enough for this added load and the use of the oil recovery system was limited to oil and water separation by settling. In addition, the capacity of the installed hardware for distributing and monitoring the flush water was not adequate to provide the additional flush water necessary for the oil recovery.

These design limitations restricted the recovery flows to inadequate rates both in Italy and New Zealand, and recovery was discontinued.

The importance of protecting the shaft seals from damage by particulates in the flush water requires that adequate water filtration be considered as part of the shaft seal system. On-board filters limiting the particle size to 25 μm or less were installed for this purpose. These filters were not adequate to remove the particulates from the filtered river water used initially in New Zealand, and deposits of particulates within the seal assemblies resulted. This design limitation was corrected by improving the prefiltration of the water. Similar prefiltration was necessary in Mexico, since without adequate prefiltration, the on-board filters plugged in about two hours, shutting down the tests.

3. Speed Control

The speed of the HSE is governor-controlled by means of a flow control valve of sliding gate design, built into the inlet of the HSE and having a 4-in. stroke. The purpose of the flow control is to provide an exact alternator speed corresponding to an electrical output of exact frequency such as 50 or 60 Hz. The testing in Utah soon showed that the flow control valve had all of the well-known flow control limitations of a gate valve. Flow was not linear with stroke, and percentage flow variation through a nearly closed valve changed abruptly with stroke. The important determining factors for use were the capacity of the valve as a function of pressure drop across it, and the response and stability relating to gate travel controlled by the governor and system hydraulics. As should be expected, idling was difficult, particularly for high-pressure fluids, because the valve was nearly closed or in a pinched condition. The valve problem was exacerbated by the very large range of specific volumes of assorted inlet fluids over the full range of both pressure and steam quality desired for machine testing and operation. The added requirement for flow control over the full range of load, from idle to full load, could not be met with a single valve with a 4-in. stroke. Replacement of the original simple sliding gate valve with a compound or multiple-gate valve was outside the scope and budget of the evaluation project associated with the Utah testing. Instead, the valve was modified for use with two sizes of trim designated as high-pressure trim and low-pressure trim. This was done during the overhaul following the shaft seal failure in 1978. However, the valve remained a simple sliding gate valve with a 4-in. stroke, albeit of interchangeable gate size. In Utah, both sets of trim were used. All of the original limitations remained except that they were displaced. Therefore the preferred trim could be selected for the application, and the stable load range set accordingly. Each trim provided its own upper feed pressure limits for idling or for operation under load for various feed qualities. The corresponding capacity of the valve limited the maximum load attainable as shown by reaching 100% open position before reaching full load for some of the tests. The design goal was for a flow control valve to handle the full range of load, from idle to full load at wellhead pressure, because it would permit a direct wellhead connection without other regulating valves, resulting in the simplest possible installation. Then other requirements such as bypass or pressure relief would be dictated by the needs of the well and not the HSE. This design goal was not achieved.

Stable speed requires that the geothermal fluid flowing to the speed control valve be uniform or change only slowly with time. It need not necessarily be homogeneous but obviously slug flow will cause instability because the govenor and speed control system cannot respond instantaneously. This presented a problem for testing over the wide range of conditions planned initially for the HSE. An 8-in. diameter feed pipe was installed to handle the large flows of low-enthalpy liquid feed calculated for some of the tests, even though it was not certain that such flows could actually pass through the control valve and into the HSE. The idea was to ensure that the tests would not be limited by the size of the feed line. The penalty was that the large feed line, with its two elbows near the speed control valve, caused phase separation of the geothermal fluid for many of the two-phase flow conditions presented to the HSE during the tests. To try to alleviate the separation, and the resulting effect on speed stability and excessive working of the governor and speed control valve, a passive mixer was fabricated and inserted into the feed pipe between the feed line automatic stop valve and the speed control valve. This was a compromise, and it was recognized that the inlet piping should be sized to the actual application. Meanwhile, the stability characteristics of the governor and speed control system were best demonstrated with all-liquid or all-vapor feed. Under these conditions, speed control system hunting, often displayed with two-phase flow, was typically absent. This hunting would not be expected to occur during base load operation when coupled to a grid because the speed would be controlled synchronously by the grid, the governor and speed control system would stay constant, and the load would vary with variation in the feed to the HSE.

B. TEST LIMITS

Assorted limits to testing the power plant were encountered for each of the tests, including for the prior work in Utah. The most significant limit for all tests was the lack of delivery to the HSE of geothermal fluid having the scaling characteristics for which the HSE was designed. This precluded closing the large clearances within the machine within the test periods. Other limits are listed below.

1. Utah: 1978 and 1979

All testing in Utah was limited to a single male rotor speed of 3000 rpm. During the 1978 testing, gradual plugging of the well limited the electrical output of the power plant to 754 kW during performance tests and to 380 kW or less during an endurance test. The endurance test was limited to 182 hours by a shaft seal failure which terminated the test one day in advance of the scheduled shutting in of the well. The testing in 1979 was limited to one month and was conducted primarily to confirm an overhaul of the HSE which included the installation of a new type of shaft seal. The testing with the new seals was limited to 100 hours, leaving endurance testing until later. The operating conditions of the well and separator plant were dictated by the needs of a different project, some of which were not compatible with the testing of the HSE. This limited the available range of test conditions and data recorded. An example of the consequences is that the HSE power plant was tested at full load for only one inlet pressure and only one inlet quality. The preferred method of adjusting the HSE inlet pressure by setting the separator pressure was not available because of other site limits or priorities. Consequently test conditions in close groups or families of inlet pressures and qualities were not attainable. This test limitation yielded an assortment of test results difficult to characterize by conventional graphical methods. The data correlations derived for the Utah test results were a result of this difficulty. The correlations were effective and were subsequently used by ENEL for treating the test data in Italy where the data were similarly assorted with respect to test conditions. This could be important to readers interested in comparing the Utah data with data from the other sites.

2. Mexico: 1980 and 1981

The capacity of the well limited the continuous electrical output of the power plant to approximately 880 kW before the earthquake of June 8, 1980 and between 820 to 860 kW afterwards. Little or no adjustment of inlet quality was possible for most tests. Tests with all-liquid feed were limited by the capacity of the well to 125-kW electrical output. During the wellhead testing in 1980, the desired scale growth within the HSE was severely limited by the placement of a pressure-reducing valve between the wellhead and the power plant, causing the majority of the scale to deposit just downstream of the valve, thus reducing the potential for deposition within the HSE. The pressure-reducing valve was used because the speed governing system cannot control the speed of the HSE over the full load range over the full range of the wellhead pressures. The condensing tests in 1981 were severely limited by the cooling water supply to the test site and by a blockage in the inlet to the condensate extraction pump.

3. Italy: 1981 and 1982

The capacity of the well limited the power production to 550 kW for a wellhead connection with unmeasured flowrate. The capacity of the separator plant limited the measured performance to a maximum electrical output of 460 kW with both separators working in parallel, and to about 260 kW with only liquid from the separators. Manipulation of the vapor/liquid ratio to intermediate values was not feasible. The test periods were limited to a total of 121 hours by rapid rates of scale deposition in the well and in the surface piping, the separators, the separator control valves, and the HSE exhaust pipe. Although scale deposited rapidly within the HSE, it did not remain on the rotors.

4. New Zealand: 1982 and 1983

The electrical output of the power plant was limited to 850 kW because of the allowable torque on the drive shaft and the reduced speed resulting from the conversion to 50 Hz for the testing in Italy. The maximum stable inlet pressure was limited to 220 psia by the use of the low-pressure inlet trim in the speed control valve. The high-pressure trim was not used.

SECTION III

TEST OBJECTIVES

The test objectives were essentially the same at all test sites, namely to determine the efficiency and reliability of the HSE using geothermal fluids under various operating conditions over an extended operating time. The determination of scaling, corrosion and operation problems was included. As a group, the operating conditions were intended to be broad enough to permit assessing the application of the HSE to any water-dominated field including the test site.

The specific test objectives differed among the three test sites but included the following:

A. MEXICO

(1) Determine the change in HSE efficiency with time;

(2) Investigate the problems that arise in the machine during long periods of operations;

(3) Perform vacuum exhaust testing of a preliminary nature; and

(4) Acquire technical information and train personnel.

The stated purpose of the tests was to determine under what conditions the use of the HSE in Cerro Prieto would be advisable.

B. ITALY

(1) Test with high-salinity fluids (310,000 ppm) direct from the wellhead and from a separator plant. (This high salinity precluded condensing testing because the lower resulting exhaust temperatures were predicted to cause excessive scale deposition in the low-pressure zones within the HSE and in the exhaust system); and

(2) Test at 50-Hz generator output, and operate coupled to the grid as much as possible. (The conversion to 50-Hz operation yielded a male rotor speed of 3333 rpm.)

Test objectives independent of the HSE were to evaluate scaling inhibitors, to investigate the possibility of the production of sodium and potassium sulfates, to carry out long-term production tests to investigate the geothermal reservoir, and to investigate a possible correlation between reinjection and seismic activity.

C. NEW ZEALAND

(1) Determine the performance at male rotor speeds of 3333 and 2500 rpm over the broadest possible range of load, inlet pressure and inlet quality. (These speeds resulted from the frequency change to 50

Hz and the original male rotor speed options of 4000 and 3000 rpm at 60 Hz); and

(2) Determine the reliability and the maintenance requirements of the HSE.

SECTION IV

TEST SITES AND WELLS

A. MEXICO

The test installation in Mexico utilized well M-11 in the Cerro Prieto geothermal field (see Appendix A, Figure A-1), during the period from December 1979 to April 1981. The chemical composition of the brine is listed in Table A-1, and the well completion and geological information are shown in Figure A-2. Well M-11 was selected because its characteristics were well-known, it did not produce sand, and it was normally stable. The well had a capacity of approximately 50 tons per hour (tons/h), which was known in advance to be undersized for testing the 1-MW wellhead generator. The capacity of the well corresponded to approximately 880 kW from the power plant, as discussed earlier. Production characteristics of the well are shown in the curves Figure A-3.

B. ITALY

In Italy the HSE power plant was installed in the Cesano geothermal field located 25 km north of Rome to make use of the Cesano 1 well for electric power production. The Cesano 1 well produced the brine shown in Appendix B, Table B-1 at about 250 tons/h. It was recognized that the Cesano 1 brine, with total dissolved solids of 364,000 mg/l, was not typical but would present an especially severe test of the HSE and its tolerance for scale.

C. NEW ZEALAND

The HSE was sited in New Zealand at well BR 19 in the Broadlands geothermal field. The well offered easily managed fluids at greater flow rates than the HSE could fully utilize. The fluid chemistry, mass output curve, and casing information with corresponding geological information are shown in Appendix C, Table C-1 and Figures C-1 and C-2, respectively.

SECTION V

PERFORMANCE EVALUATION METHODO! .

The helical screw expander power plant consists primarily of t. HSE driving a conventional alternator through a conventional speed reducer. The efficiency and performance characteristics of alternators and speed reducers are well-known. Since the HSE is the novel piece of equipment in the power plant, it is the efficiency and performance characteristics of the HSE that are of most interest in this Task. Other efficiencies such as power plant effi-ciency or thermal efficiency can be determined but were optional.

For the purpose of the performance evaluation of the HSE, the machine efficiency is defined as

$$Eff = \frac{KWM}{M1\ (h_1 - h_{2S})}$$

where

KWM = HSE shaft output power

M1 = Mass flowrate of fluid through the HSE

h_1 = Specific enthalpy of fluid entering the HSE at inlet pressure P1 and inlet temperature T1

and

h_{2S} = Specific enthalpy that would result from the isentropic expansion of the fluid from the HSE inlet condition to the outlet pressure P2

This is the standard equation for machine efficiency or isentropic efficiency under steady-state operation and is equal to the ratio of the actual work done by the expanding fluid to the work of an ideal expansion of the same fluid over the same pressure interval.

None of the variables in the efficiency equation are normally measured directly. The value of h_{2S} is calculated from h_1 and the thermodynamic properties of the fluid at the inlet and outlet pressures. KWM, M1 and h_1 must be determined experimentally. The HSE shaft output power KWM is determined by measuring the electrical output of the alternator KWe, and adding the alternator and the speed reducer losses. The alternator and speed reducer were factory-calibrated for 60-Hz operation prior to installation in the power plant to determine the losses over the entire load range (Ref. 1, p. G-3). The power loss equations were modified for 50-Hz operation as appropriate (Ref. B and C).

The flowrate M1 and the inlet enthalpy h_1 can be determined for the typical case by separating the flow into single-phase vapor and liquid streams whose flowrate and enthalpy can be determined and recombined to provide a stream of known flowrate and enthalpy to the HSE. This procedure was used by each of the Host Countries and in the prior work.

Alternatively, the flowrate through the HSE and the exhaust enthalpy can be determined by measuring the vapor and liquid streams produced by separating the exhaust. For an actual expander the sum of the power output plus thermal losses equals the product of the flowrate and the actual change in enthalpy. Since the thermal losses are small and can be neglected, the inlet enthalpy can be calculated easily. This procedure of HSE efficiency determination by downstream determination of flowrate and enthalpy was used at well M-11 in Mexico to allow a true wellhead installation of the power plant. (For more details of these two procedures see Ref. 1, pp. 5-1 to 5-4.)

SECTION VI

INSTALLATION

A. PROCESS LAYOUTS

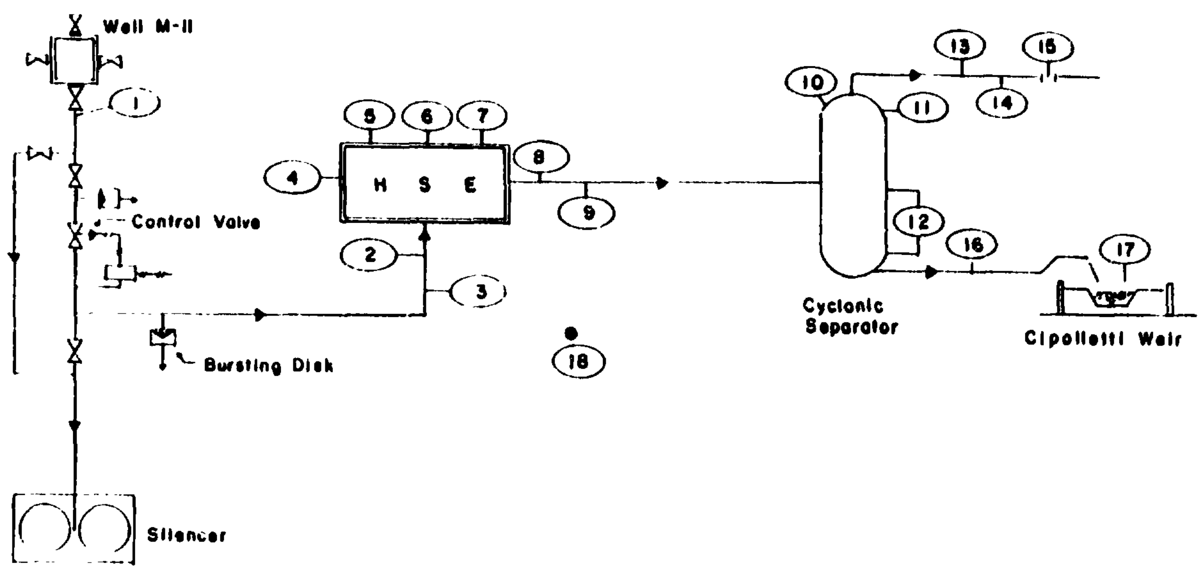
1. Mexico

Two process layouts were used at well M-11 in Cerro Prieto. The first provided a wellhead line that bypassed an existing separator to carry fluid through a pressure control valve to the HSE. The exhaust from the HSE passed through an atmospheric separator which vented the steam to the atmosphere through an orifice and sent the brine to a weir channel. Measurements on the two streams allowed the exhaust flowrate and enthalpy to be determined. The process schematic is shown in Figure 6-1 (see also Ref. 1, p. 5-7).

Surplus fluid flow from the well was bypassed from the wellhead to waste through an atmospheric silencer. For installation and operating simplicity, and because of the small capacity of the well, no provision was made to manipulate the fluid quality to the HSE. The quality varied among the various tests from approximately 10% to 30% according to the amount of flashing that occurred as the fluid passed up the well and through the pressure control valve and according to the amount of fractionation that occurred as part of the fluid was bypassed to waste under selected HSE inlet pressures and loads. The fractionation occurred mostly because the flow path was straight toward the pressure control valve and HSE but turned 90° into the bypass.

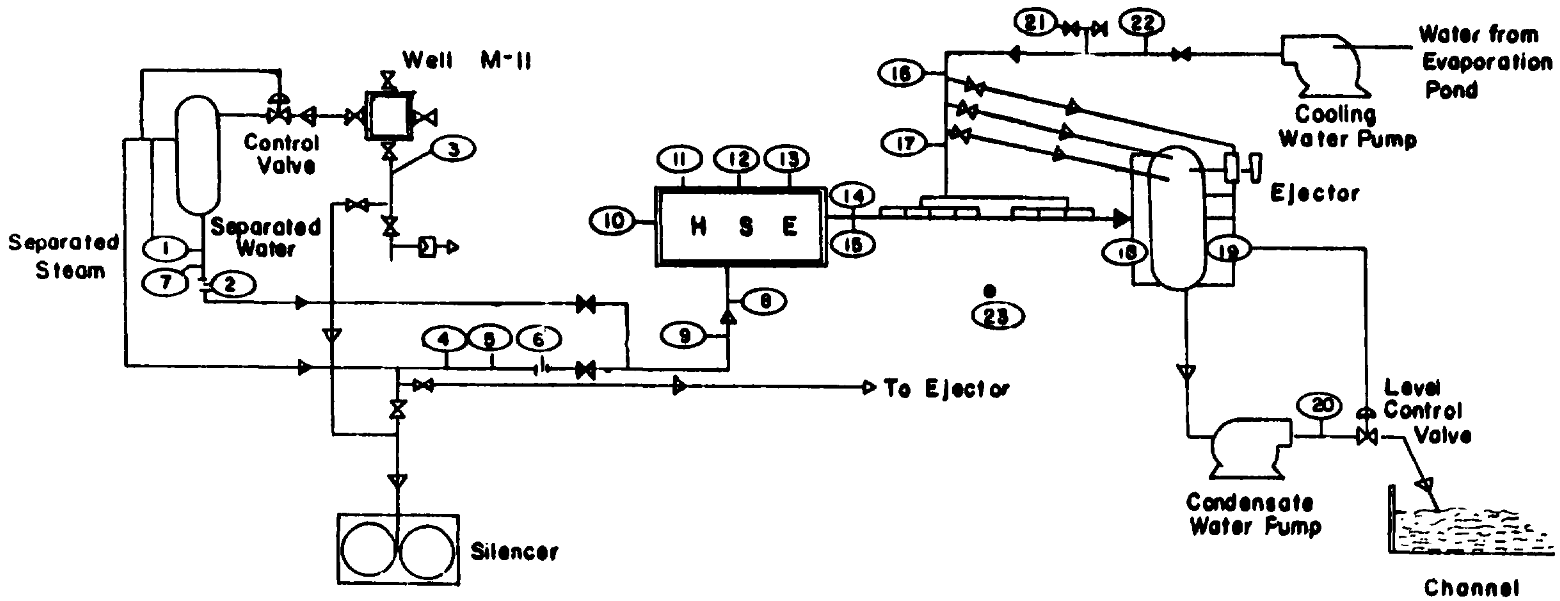
This process layout, Figure 6-1, was used in 1980 for noncondensing performance tests at various inlet and outlet pressures and loads and for endurance testing at the full capacity of the well. The provision for elevated back pressure is not shown in Figure 6-1 but the equipment used is described in Ref. 1, pp. 5-27 and 5-29.

The process layout shown in Figure 6-1 was modified to permit some preliminary vacuum exhaust testing. The plan was to make use of existing or readily available equipment. The exhaust separator was converted into a condenser and was fitted with a steam jet ejector and a condensate extraction pump. Cooling water from the evaporation pond (see Figure A-1) was transported approximately 900 ft to the condenser through a pipeline normally used as a waste line for the brine from the wellhead separator when the steam from well M-11 was delivered to Cerro Prieto power plant C.P. 1. Scale in the pipe had reduced the inside diameter to about 5 in. The wellhead separator, not shown in Figure 6-1, was reinstalled for the vacuum exhaust testing to provide separated steam and water streams, thus permitting measurement and recombining of the streams for delivery to the HSE at a known flowrate and enthalpy. The process schematic for the vacuum exhaust testing is shown in Figure 6-2. This process installation also permitted testing the HSE with atmospheric discharge by venting the condenser to atmosphere. A bypass on the steam line from the separator permitted venting the steam to the silencer for testing the HSE on all-liquid feed at low power. Another bypass also connected the wellhead directly to the silencer, again at right angles to the flow to the pressure



MEASURING INSTRUMENTS	RANGE	MEASURING INSTRUMENTS	RANGE
1 - Well Pressure	0 - 1000 psia	10 - Separator Pressure	0 - 50 psia
2 - Inlet Pressure	0 - 500 psig	11 - Separator Temperature	0 - 250 °F
3 - Inlet Temperature	227 - 505 °F	12 - Separator Level	0 - 130 In of Hg
4 - Current	0 - 1500 ampere	13 - Separated Steam Pressure	0 - 50 psia
5 - Voltage	0 - 600 volt	14 - Separated Steam Temperature	212 - 499 °F
6 - Frequency	55 - 65 Hz.	15 - Separated Steam Differential Pressure	0 - 100 In of H_2O
7 - Power	0 - 4000 watt	16 - Separated Water Temperature	32 - 250 °F
8 - Outlet Pressure	0 - 50 psia	17 - Water Head	0 - 25 In of H_2O
9 - Outlet Temperature	0 - 500 °F	18 - Atmospheric pressure	0 - 50 psia

Figure 6-1. Process Schematic and Instruments: Atmospheric Pressure Discharge Tests, Mexico (Ref. A, Fig. 4)



MEASURING INSTRUMENTS	RANGE	MEASURING INSTRUMENTS	RANGE
1 - Separator Level	0 - 750 in of H_2O	12 - Frequency	55 - 65 Hz.
2 - Separated Water Differential Pressure	0 - 30 in of H_2O	13 - Power	0 - 4000 watt
3 - Well Pressure	0 - 1000 psia	14 - Outlet Pressure	0 - 50 psia
4 - Separated Steam Temperature	50 - 500 °F	15 - Outlet Temperature	0 - 500 °F
5 - Separated Steam Pressure	0 - 600 psig	16 - Pond Water Pressure	0 - 800 psig
6 - Separated Steam Differential	0 - 150 in of H_2O	17 - Pond Water Temperature	20 - 240 °F
7 - Separated Water Temperature	50 - 500 °F	18 - Condenser Water Level	0 - 750 in of H_2O
8 - Inlet Pressure	0 - 400 psig	19 - Condenser Water Valve Control Level	0 - 15 in of H_2O
9 - Inlet Temperature	227 - 505 °F	20 - Condensate Water Temperature	101 - 219 °F
10 - Current	0 - 1500 ampere	21 - Pond Water Differential Pressure	0 - 100 in of H_2O
11 - Voltage	0 - 600 volt	22 - Pond Water Temperature	59 - 115 °F
		23 - Atmospheric Pressure	0 - 50 psia

Figure 6-2. Process Schematic and Instruments: Subatmospheric Pressure Discharge Tests, Mexico (Ref. A, Fig. 5)

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control valve and HSE. The main purpose of this bypass was to regulate the wellhead pressure to give the optimum pressure drop across the pressure control valve. The combined effects of the amount of flashing and fractionation with the bypass resulted in inlet qualities to the HSE ranging from 10% to 34% except for the few tests on all-liquid feed.

2. Italy

The process layout at Cesano 1 well was designed as a pilot plant not only to test the HSE but also to investigate the production and recovery of chemicals from the geothermal reservoir. The pilot plant, shown in Figure 6-3, featured two primary or wellhead separators installed for parallel operation to permit alternate usage and cleaning. Brine from the primary separators could be subjected to a second controlled flash into a secondary separator for the chemical studies. Various features of the pilot plant that were designed to accommodate the severe scaling characteristics of the well are discussed in Ref. 8. For the HSE tests, liquid and vapor streams from the primary separators were measured and recombined for delivery to the HSE at known flowrate and enthalphy, as shown in the process schematic in Figure 6-4. Provisions for venting vapor and liquid from the primary separators permitted varying the vapor/liquid ratio in the feed to the HSE. These separators were designed to operate at wellhead pressure and were undersized for the HSE tests. The pilot plant was modified so that the two separators could operate simultaneously, and a line was installed for operating the HSE directly from the wellhead as shown in the process schematic in Figure 6-5.

3. New Zealand

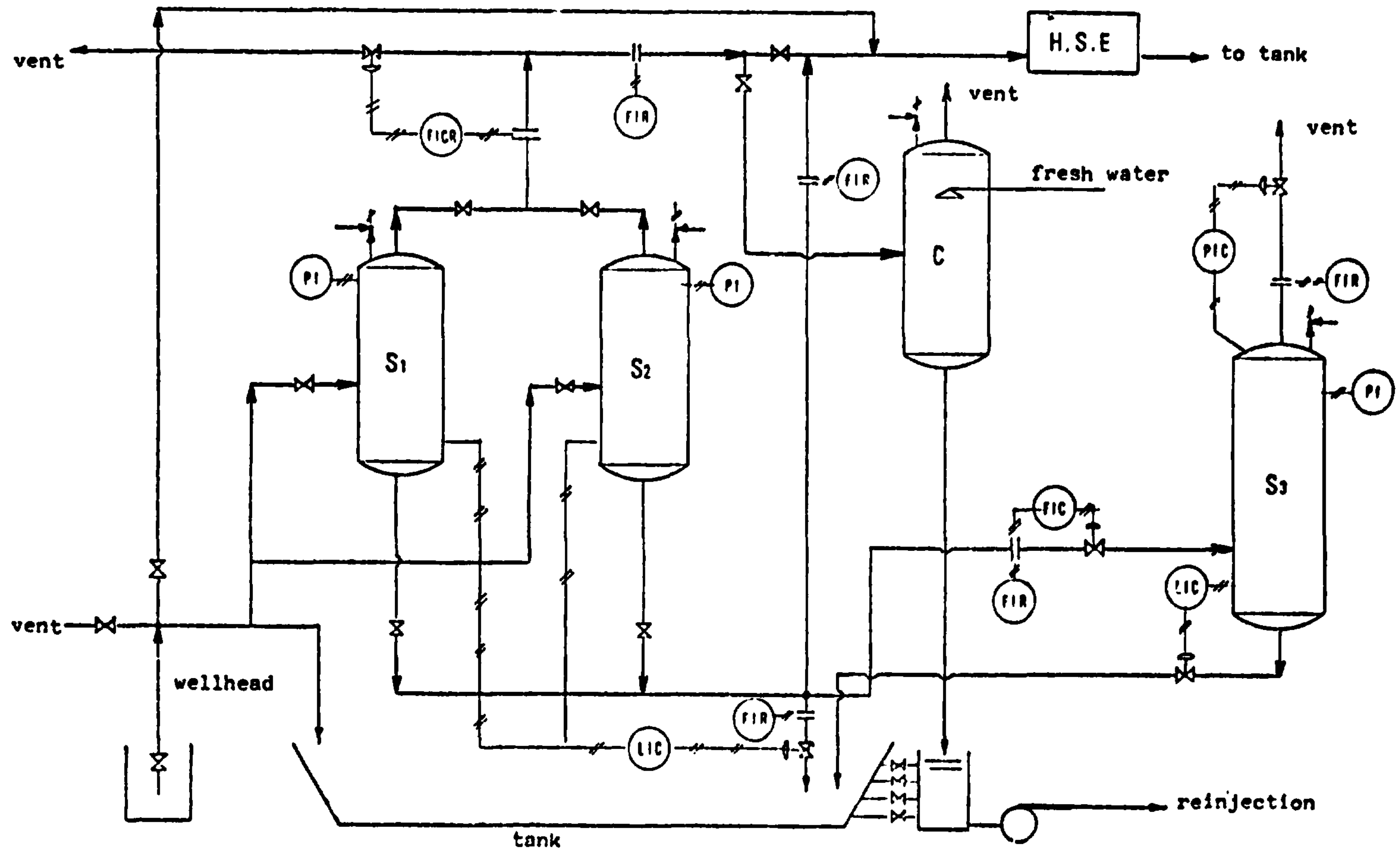
The process layout at Broadlands well BR 19 consisted of a wellhead leg carrying geothermal fluid to a separator plant with associated pipework carrying the fluid to the HSE. The separated steam and liquid flows were measured, recombined, directed to the HSE, and finally discharged through an atmospheric silencer to waste. Surplus fluid flow from the well was bypassed to waste through a second atmospheric silencer. A process schematic is shown in Figure 6-6.

Flow from the well to the separator was controlled by a pressure control valve either automatically from the separator pressure by means of a pressure control unit or manually from an auto-manual control station. The liquid level in this separator was controlled manually with the hand valve on the liquid bypass line to the bypass silencer.

The process layout enabled the fluid quality to be varied across the range of fluid compositions, from all-liquid to all-steam, and enabled the mass flowrate and enthalpy of the fluid entering the HSE to be determined.

B. SHAFT SEAL WATER

A reliable water supply low in calcium hardness and particulates was required for the shaft seal assemblies in the HSE to provide an expendable barrier between the seals and the brine. The design rate of consumption was about 4 gpm. A different type of water source was used at each test installation.



S1, S2 primary separators
S3 secondary separator
H.S.E. helical screw expander
C condenser

Figure 6-3. Pilot Plant Equipment Flow Sheet, Italy (Ref. B, Fig. 1)

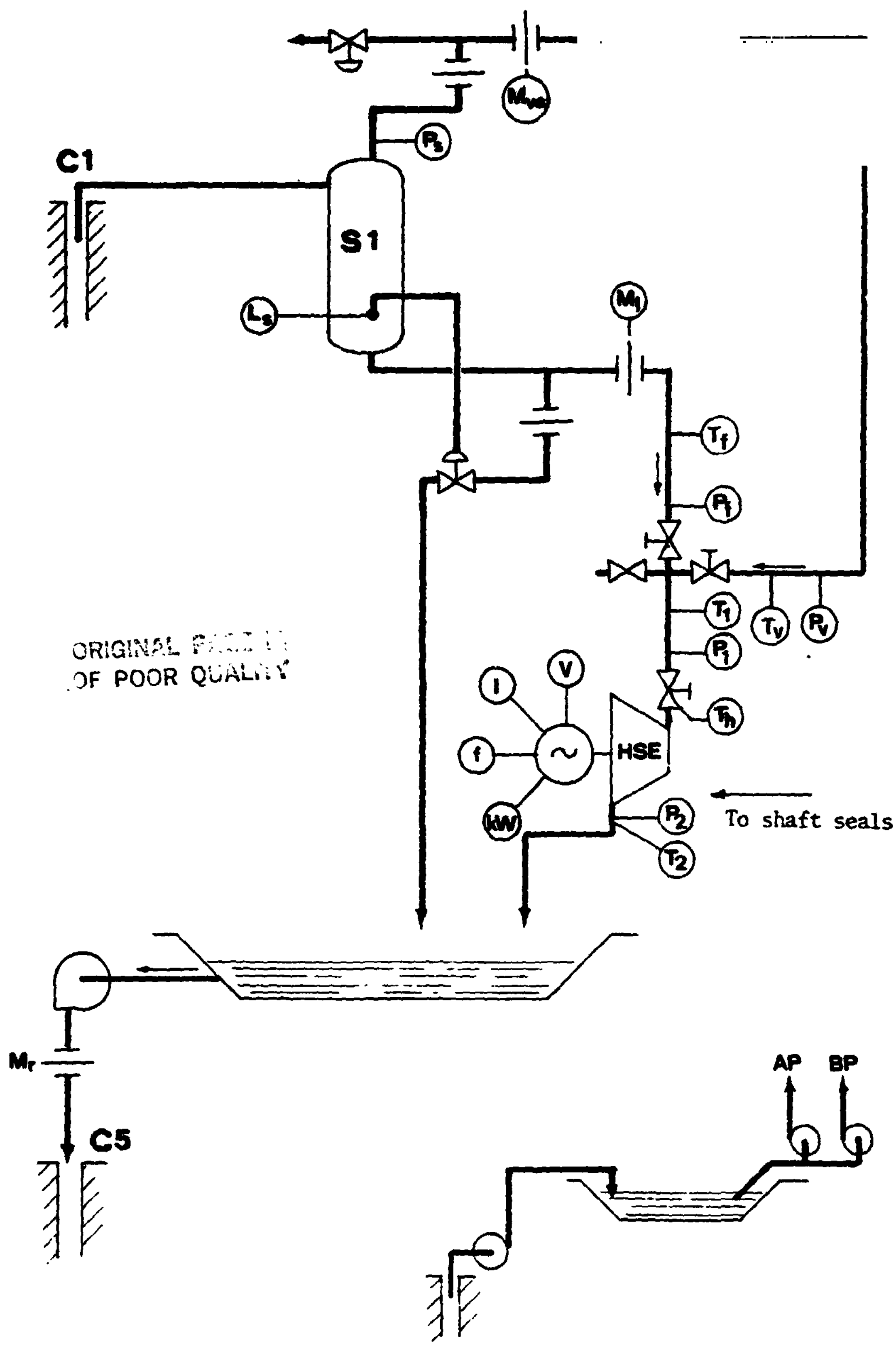


Figure 6-4. Process Schematic:
HSE Operating from Separator, Italy (Ref. 8, Fig. 6)

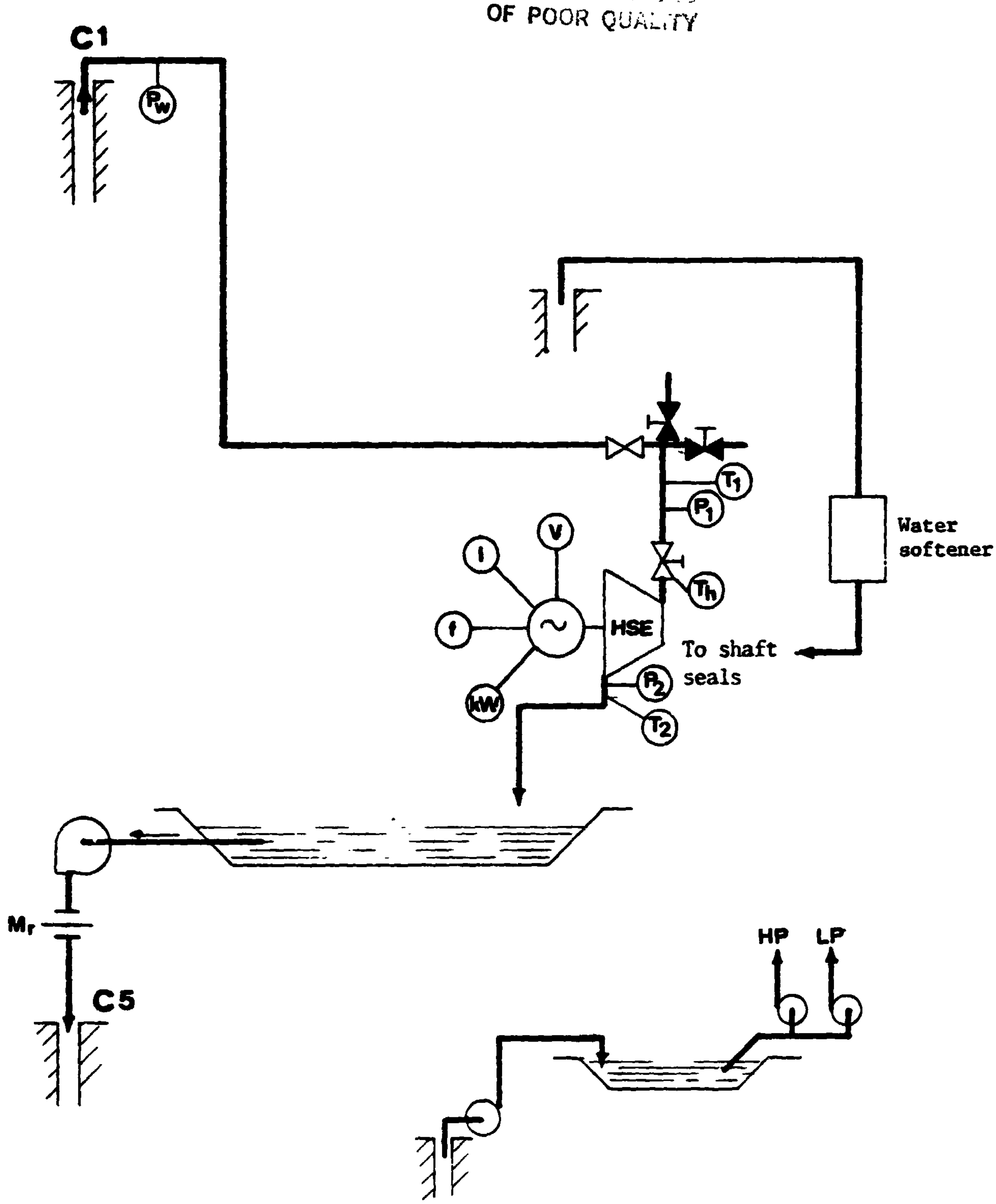


Figure 6-5. Process Schematic:
HSE Operating from Wellhead, Italy (Ref. B, Fig. 5)

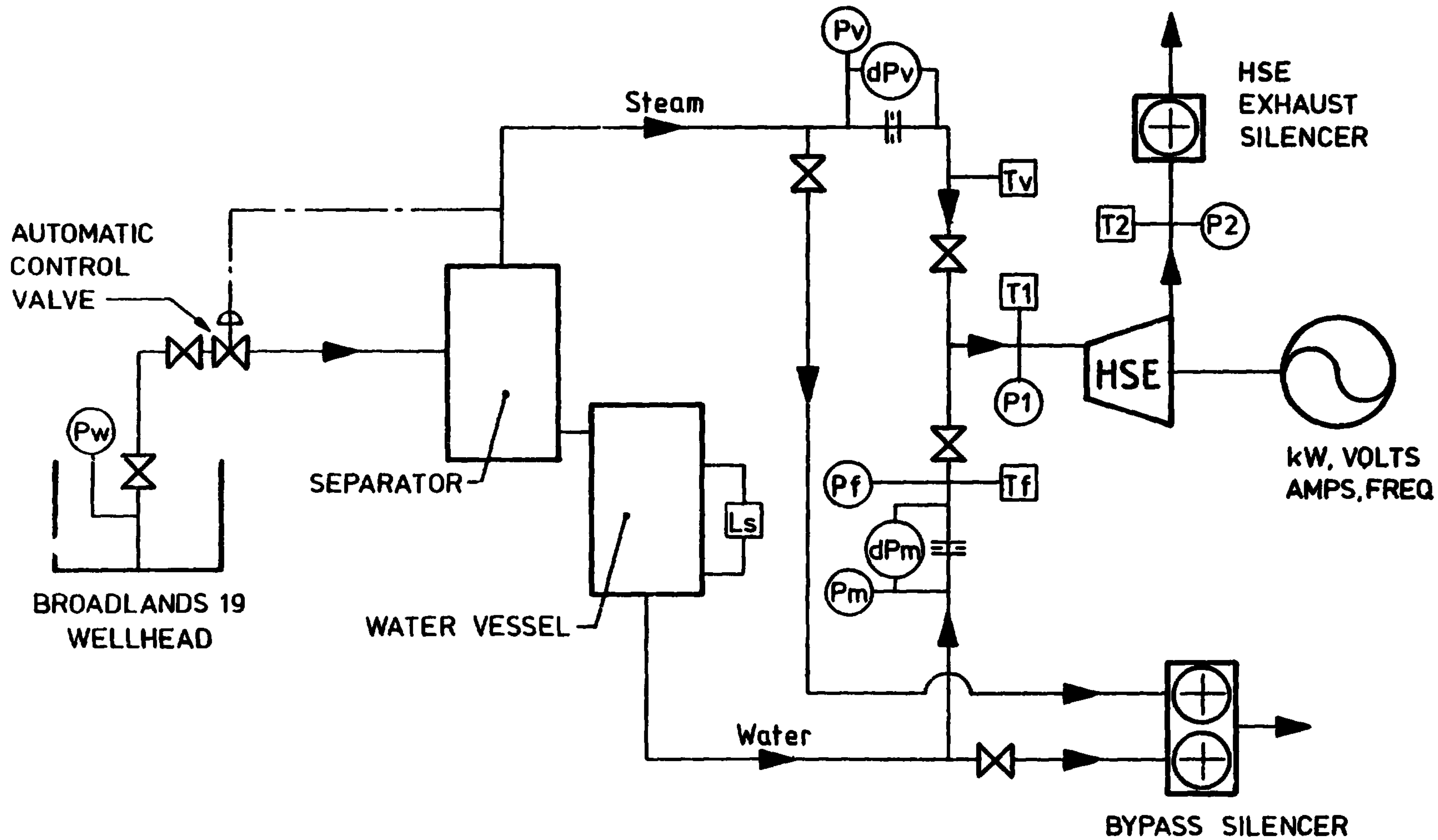


Figure 6-6. Process Schematic, New Zealand (Ref. C, Fig. 3.1)

1. Mexico

At Cerro Prieto, water for the shaft seals was supplied from the cooling tower of power plant C.P. 1. and transported by 2-in. pipe a distance of approximately 1 mile. Because a cooling tower is a wet scrubber that .emoves dust from the air, the water was heavily laden with particulates, and filtration was necessary. Because the transport pipe was old and contained scale deposits, the water arrived at the well site with excessive amounts of calcium ions, and water softening was necessary. The water from the transport pipe was passed in sequence through a booster pump, a filter, standard household cation exchange water softeners, a second filter, a second booster pump, a third filter, and into a covered holding tank. The first and third filters were readily available diatomaceous earth filters made for use with home swimming pools. These filters replaced earlier filters that were not satisfactory. The second booster pump and the second and third filters had sufficient capacity to allow a stream of water to be withdrawn from the holding tank and recycled through the second and third filters. The process layout is shown in Figure 6-7. The water chemistry of samples taken from the holding tank (or main container) is included in Table A-2. The storage pond shown in the layout was installed originally to hold water brought in by tank truck, but this method of supply proved unsatisfactory, either because of ground water encroachment or salt spray fallout from the air for certain wind directions. Water from the pond was not used. Some of the impurities in the water from the tower may have been salts scrubbed from the air. Close attention to the water treatment and water quality was very important. The diatomaceous earth filters normally remove particles down to 1 μm size or smaller, but polishing filters on the power plant were left in place to remove particles down to 25 μm in case of upset. Until the diatomaceous earth filters were installed, the polishing filters plugged in about wo hours of operation, tripping the safety shutdown system. Hydrogen sulfide carried in the water from the cooling tower was corrosive and was not removed. (See Section IX for a report of corrosion.)

2. Italy

Water for the shaft seals was obtained from a shallow well and was treated in a commercial-size water softening system shown schematically in Figure 6-5 before being sent through the polishing filters on the power plant.

3. New Zealand

Water low in calcium and sodium carbonate hardness was obtained indirectly from a river that passed near the site. The seal flush water supplied to the HSE was prefiltered to levels exceeding the manufacturer's specification of 25 μm. During the performance tests, water filtration to a level of 12 μm was performed using cartridge filters. After these tests, inspection of one shaft seal assembly showed seal damage, apparently from abrasion and particulate matter within the assembly. Therefore, for the endurance test, a diatomaceous earth system was installed to perform prefiltration to a level of 1.5 μm.

C. LOAD

At all installations the electrical energy generated by the power plant was dissipated in a resistive load bank supplied as part of the test equipment

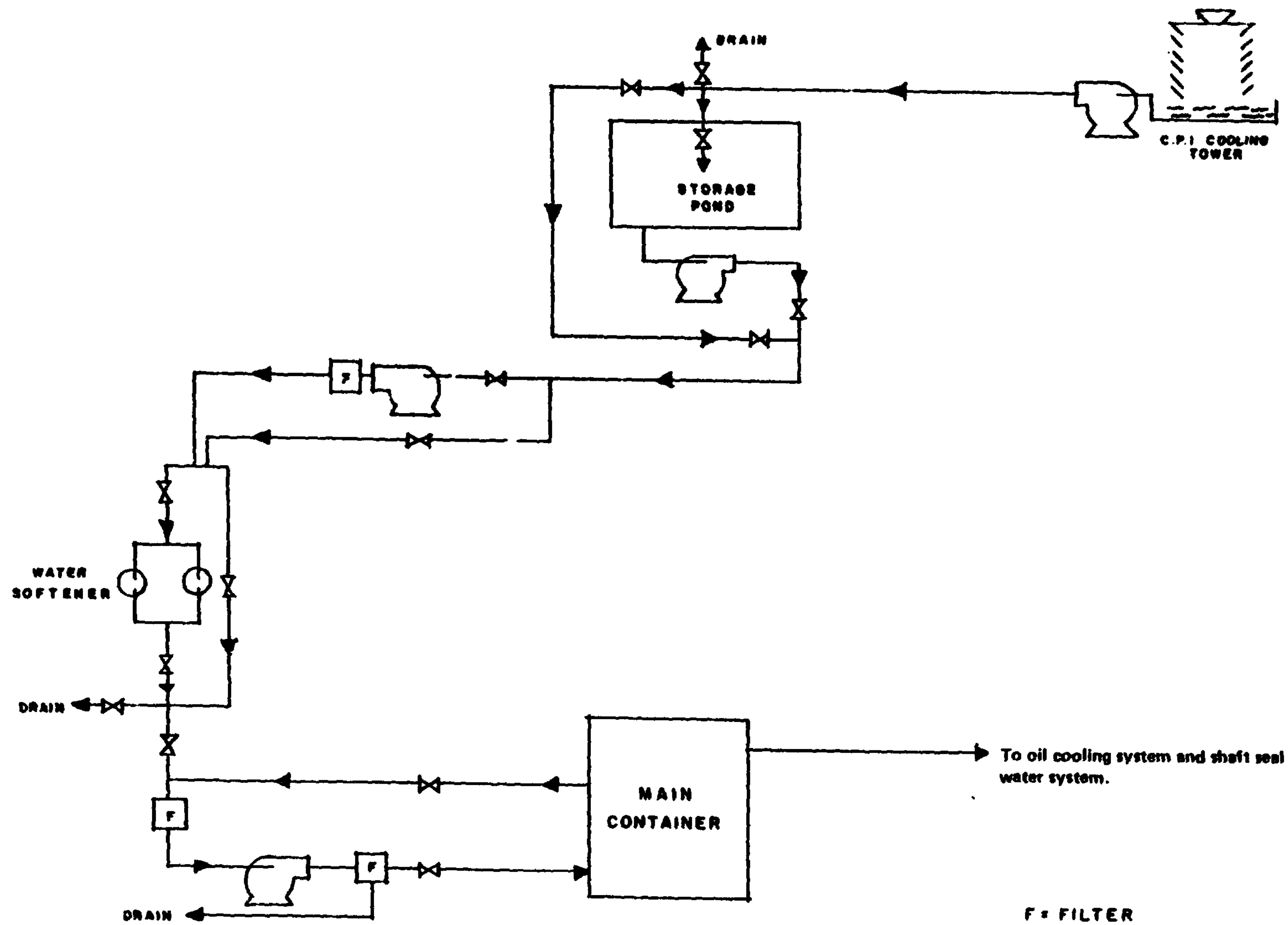


Figure 6-7. Water Supply System, Mexico (Ref. A, Fig. 7)

and described in Ref. 1, p. 2-17. In preparation for the testing in Italy, the power plant was converted from 60 Hz to 50 Hz and the output voltage was reduced from 480 V to typically 430 V. Loads could be incremented in steps of 50 kW at 480 V as in Utah and Mexico and in increments of approximately 40 kW at 430 V as in Italy and New Zealand. In Italy for some of the testing the power plant was connected with the Italian electrical grid according to the electrical sketch shown in Figure 6-8. No attempt was made to synchronize with the Mexico or New Zealand electrical grids due to the distance of the sites from suitable transmission lines.

D. AUXILIARY POWER

Auxiliary power was provided by diesel generators at the test sites in Mexico and New Zealand. In Italy, auxiliary power was provided from the Italian electrical grid.

E. PROCESS AND PERFORMANCE MONITORING

1. Instruments

All installations were instrumented to enable performance and selected process variables to be logged. The locations of the instruments monitoring the performance variables are shown on the process schematics for each installation, in Figures 6-1 through 6-6. For the Cerro Prieto installations, the process variables are listed on the schematics, Figures 6-1 and 6-2, and for the Cesano and Broadlands installations they are listed separately, as nomenclature in Table B-2 for Cesano, and as variables logged in Table C-2 for Broadlands. The similarity in the lists of variables is readily apparent and is to be expected. Table C-2 includes HSE bearing temperatures and alternator winding temperatures which were measured at all sites.

The list of transducers used in the Broadlands installation is presented in detail in Table C-3 and may be considered typical. This list is part of a longer list of the transducers that were used in the prior work in Utah.

All the process transducers were calibrated for each installation prior to the commencement of the testing using the same calibration equipment, and checks were performed during the testing to ensure reliable data were being logged.

In the interest of consistency, wherever possible the same instruments were used at all of the test sites, although in some cases the assignment within the process schematic was rearranged.

Notable instrumentation differences among the installations were as follows:

a. Mexico. In the first process installation in Cerro Prieto (see Figure 6-1), the measurement of liquid separated from the HSE exhaust was by weir. All other measurements of flow of fluid through the HSE were by orifice. The vapor measurements used flange taps as had been done in Utah, whereas the liquid measurement in the second process (see Figure 6-2) used pressure taps at D and D/2 locations according to the ASME convention.

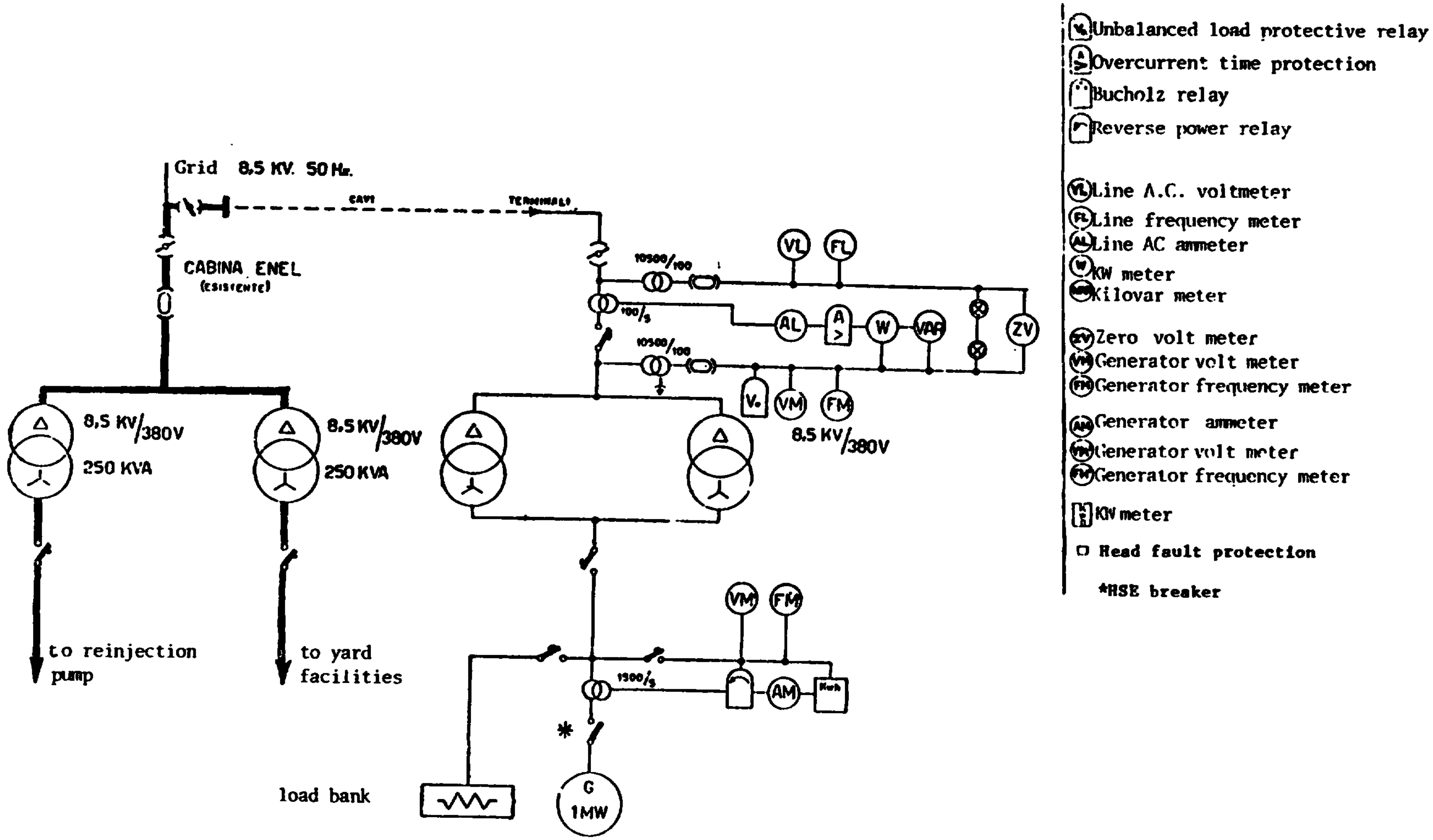


Figure 6-8. HSE Connection to Italian Electrical Grid (Ref. B, Fig. 7)

b. Italy. At Cesano 1, the flow of liquid from the separator for delivery to the HSE was measured by a magnetic flowmeter with a removable electrode. The metering tube was of PTFE, serviceable to 180°C and 40 bar. Cold water was injected upstream of the magnetic flowmeter to avoid boiling within the meter. The flowrate of the vapor phase was measured by orifice with D and D/2 taps conforming to ASME convention.

c. New Zealand. In the Broadlands installation, flowrates were metered using D and D/2 orifice plates conforming to the British Standard, BS 1042 Pt. 1. As in Utah and Mexico, the water orifice plate was installed with sufficient head to avoid flashing at the orifice.

2. Data Acquisition

The data acquisition system was built around Hewlett-Packard equipment and is described in detail in Ref. 1, pp. 2-17 to 2-42. Each Host Country adapted the computer programs supplied to suit the corresponding installation. The operating programs calculated, on-line, the isentropic efficiency of the HSE. The equations specific to the Mexican, Italian and New Zealand test programmes are documented in Refs. A, B and C, respectively. All operating programs logged test data on tape cassettes automatically at pre-set intervals and by operator command.

The instrumentation and data logging facilities enabled easy, reliable monitoring and recording of the data generated from the test programs at all sites.

SECTION VII

TESTING

A. MEXICO

Tests were done to measure the performance of the HSE and power plant under various process conditions and to assess the durability and operational problems of the equipment. The test activities were carried out approximately as follows (Ref. A):

(1) Equipment Reception and Installation:
December 1, 1979 - February 10, 1980

During this period the power plant was installed at well M-11 according to the process schematic of Figure 6-1 for testing with atmospheric pressure discharge. All other equipment installations were started.

(2) Auxiliary Equipment Installation and Verification:
February 11, 1980 - March 30, 1980

Auxiliary test support equipment was installed and tested. The data acquisition system for use with the computer was verified and the instruments were calibrated and installed.

(3) Various Test Exercises:
March 31, 1980 - May 31, 1980

The HSE was operated at different inlet pressures and loads at 3000-rpm male rotor speed. Necessary changes were identified and made in the mechanical subsystems throughout the period. Approximately 17.67 MWh of electricity were generated during 70 hours of testing. Data obtained during this period were preliminary pending instrument installation improvements and completion of the computer program.

(4) Endurance Test:
May 31, 1980 - July 29, 1980

The power plant was operated at full well capacity to determine durability and operational problems. Nominal conditions were inlet pressure 180 psia, inlet quality 22%, and electrical load 850 kW. The test was interrupted on June 8 by an earthquake, on June 18 by a steam leak, on June 26 by variation in the wellhead pressure, on July 8 by a ruptured disc, on July 15 by high wellhead pressure, and on July 20 by a load bank problem. The test totaled approximately 985 hours of operation, during which 826.5 MWh of electricity were generated.

(5) Various Tests:
July 29, 1980 - August 28, 1980

During this period, tests were carried out at 3000- and 4000-rpm male rotor speeds at different inlet and outlet pressures, inlet quality and applied loads. The range of operating conditions was as follows:

Inlet pressure, nominal (psia)	100, 140, 180
Inlet quality, random (%)	10 to 34
Exhaust pressure	Atmosphere and 25 to 40 psia
Electrical load (kW)	211 to 857

Approximately 3.45 MWh of electricity were generated during the 9.23 hours of these various tests.

(6) Condenser Installations:
September 1, 1980 - December 4, 1980

During this period the installation was revised to carry out condensing tests according to the process schematic of Figure 6-2. The auxiliary changes were made, and the computer program was adapted to analyze the machine behavior under the new testing conditions.

(7) Installation Exercises:
December 5, 1980 - January 28, 1981

The installation was subjected to various exercises to verify the installation and computer program revisions. Necessary adjustments and equipment repairs were identified and made throughout this period.

(8) Various Tests:
January 29, 1981 - February 20, 1981

During this period, tests were run at 3000- and 4000-rpm male rotor speed, at different inlet and outlet pressures and applied loads. The range of operating conditions was as follows:

Inlet pressure (psia)	64 to 183
Inlet quality (%)	near 0 to 26
Exhaust pressure (psia)	3.1 to 16.2
Electrical load (kW)	123 to 933

These tests were performed during 37.35 test hours during which 10.1 MWh of electricity were generated.

(9) Equipment Disassembly:
February 23, 1981 - April 15, 1981

The disassembly of the equipment and preparations for shipment to Italy were carried out. During this period the following items were changed by HPC as part of the conversion of the power plant for the 50-Hz operation in Italy:

a. Alternator exciter
b. Overspeed switch
c. Underspeed switch
d. Frequency meter on power plant
e. Frequency meter in data van
f. Kilowatt transducer
g. Oil booster pump motor
h. Centrifuge system: transmission gears, clutch, solenoid

In addition, the 50- and 60-Hz kilowatt transducers and the kilowatt hour meter were factory-calibrated.

B. ITALY

The testing of the HSE was part of a broader programme of experimental activity planned for this test installation.

The tests at Cesano 1 well were designed to determine the efficiency and reliability of the HSE when operating on highly scaling fluids and to demonstrate the operation of the HSE power plant connected to the national electrical grid.

It was known in advance that the rapid rates of scale deposition would create serious test difficulties.

The operating periods of the Cesano 1 test installation for September 1981 through April 1982 are summarized in Figure 7-1. The site operations include tests of the pilot plant without the HSE, scale inhibitor tests, testing of the HSE, and cleaning of the well. As can be seen from the figure, the testing of the HSE occurred mostly during November 1981 and March 1982. The chronology of site operations, from July 20, 1981 when the HSE arrived at the site through June 25, 1982 when it was shipped, is presented in Table B-3. These operations are summarized as follows:

(1) Equipment Reception and Installations:
July 20, 1981 - October 5, 1981

The installation of the Cesano 1 (Figure 6-3) pilot plant without the HSE was finished at the end of July 1981. The HSE and associated equipment arrived on the site July 20, 1981. The HSE hook-up was finished around October 5 (Figure 6-4). The fluorescent lights and the air conditioner in the data van were changed for the 50-Hz operation, and a 115-V, 3-kW transformer power supply was installed. Down-well scale inhibitor tests were done during this period.

(2) Well Cleaning and Data System Preparation:
October 6, 1981 - November 17, 1981

Following the down-well scale inhibitor tests, it was necessary to clean the well and prepare it for testing the HSE. At the same

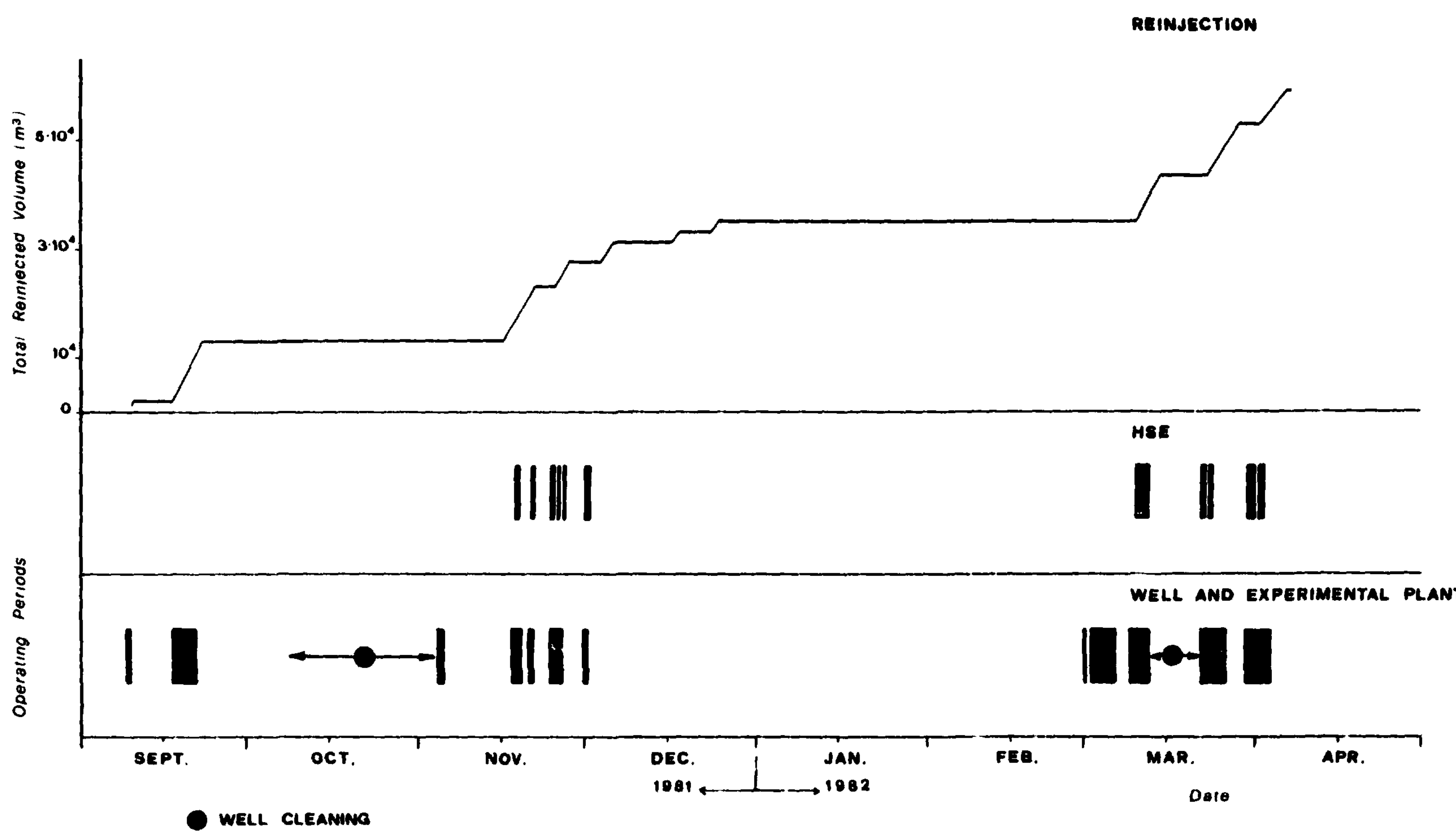


Figure 7-1. Summary of Operating Periods of the C1 Pilot Plant, Italy (Ref. B, Fig. 2)

time, the instruments were calibrated, installed and checked, and the computer program supplied with the equipment was adapted for use at this installation. Program revisions for the thermodynamics of the Cesano 1 fluids were deferred.

(3) Initiation of HSE Performance Test Operations:
November 18, 1981 - December 2, 1981

The HSE was tested intermittently under various conditions to determine its performance on Cesano 1 fluids. The initial test was attempted with only vapor from the separator but in order to produce an adequate flow of vapor it was necessary to overdrive the separator because it was too small. Scraping noises and chatter in the HSE began before the HSE was up to temperature and full speed, and were believed to be caused by scale deposits from brine carry-over in the vapor. The reasons for starting the operation on the vapor phase was to achieve stable HSE operation with a machine free of scale and then to monitor performance changes as the scale deposition occurred, but the rapid scale deposition made this impossible. Test operation was resumed using the liquid phase. The scraping and chatter occurred again and occasional strong vibrations were noted. This behavior was assessed and it was decided to continue the tests.

Rapid scale growth throughout the process piping impeded the test operations. Many stops were necessary to clean the filter basket (Figure 7-2) in the inlet separator. For the December 2 test, the basket was cleaned ten times.

During some of the tests, the HSE exhaust port and exhaust pipe experienced a glaserite scale growth of about 2 cm/h. The problem was partly reduced by injecting fresh water into the exhaust through ports in the exhaust housing. Assorted samples of scale (shown in Figure 7-3) include, from within the HSE exhaust region, pieces with cylindrical faces shaped by the rotors.

The strongest vibrations within the HSE were believed to have been caused by scale coming loose within the machine and interfering with the rotors, with lesser vibrations or chatter being caused by scale still attached. Eventually seals in three of the four shaft seal assemblies became damaged, leading to abnormal oil consumption in excess of 10 gph after about 26 hours of operation including idling without load. The test activities were halted to repair these shaft seals, to clean the process installation and to make minor process changes. Before the test activities were halted, the power plant was connected to the grid for 14 hours.

The test activities in November and December produced a total of 7.74 MWh of electrical energy during 23.46 hours of electricity production. The tests showed a need to increase the fluid supply to the expander, both through the separator for measured performance and directly from the wellhead for test and demonstration purposes.

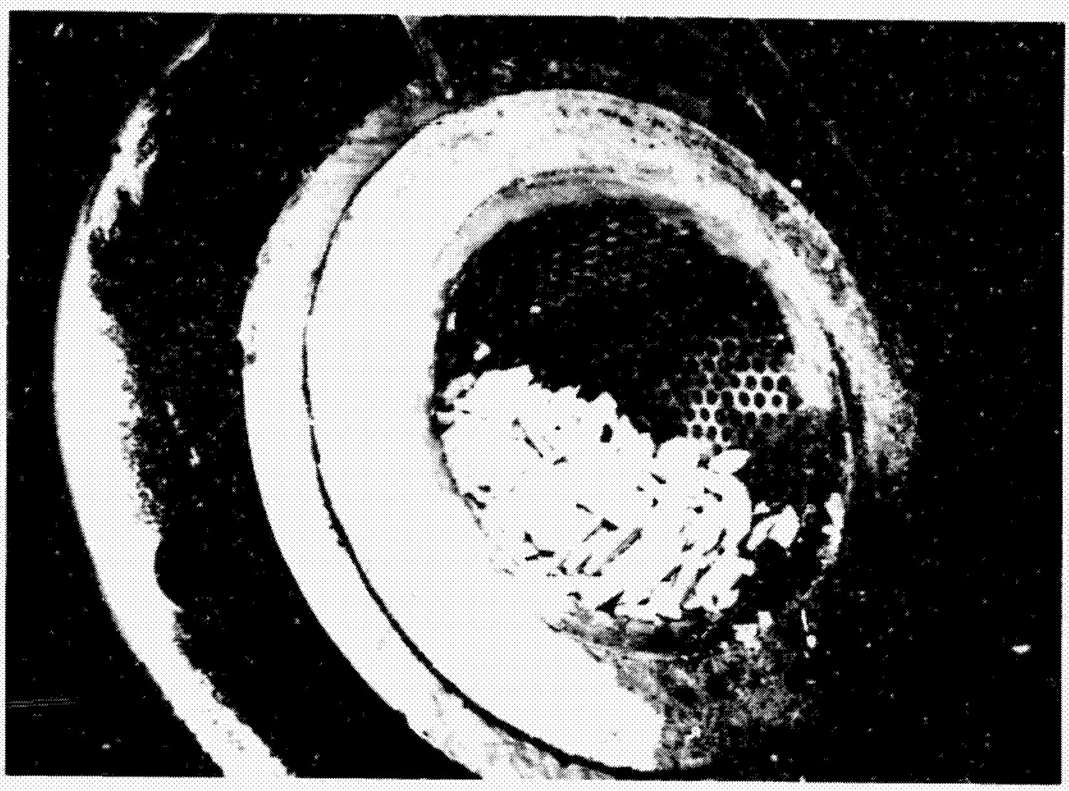


Figure 7-2. Filter Basket, Italy (Ref. 8, Fig. 11)

Figure 7-3. Assorted Samples of Scale, Italy

(4) Shaft Seal Repair and Process Installation Renovation:
December 2, 1981 - March 10, 1982

Thorough inspection of the damaged shaft seals showed that some of the carbon segments had cracked at the notch that was provided for a locking pin. No wear on any of the races or other sealing surfaces could be detected. The total operating time on the seals was then 1224 hours.

The repair involved revising the locking pins to distribute the stress in the carbon segments, using an existing set of spare seal assemblies. Secondary passages or bleed ports were provided in the seal assemblies to allow the recapture of the oil that normally leaks past the seals into the flush water. Appropriate recapture passages were machined into the HSE housing to allow recovery of the recaptured oil. This oil recapture and recovery scheme was considered during the designing of seals but was not implemented at that time (see Section II.A). The improved seal assemblies were installed; the fourth, undamaged assembly remained in the HSE. No bleed port or recovery passages were installed for the fourth assembly, and none of the other three was connected for use at this time. The centrifuge was not large enough for this added load and there was neither time nor money for alternative measures.

In the process installation, the valves, separators and pipelines were cleaned. A new, large cone-filter was designed and installed upstream of the HSE to avoid the many stops due to the clogging of the basket filter. A new pipeline was installed between the wellhead and the new filter, and piping changes were made so that the S1 and S2 separators (Figure 6-3) could be operated simultaneously to increase the fluid supply to the HSE.

(5) Continuation of Performance Tests:
March 10, 1982 - March 11, 1982

Performance tests were made at loads up to 460 kW, the maximum available with fluid from the two separators working in parallel. Loss of oil through the new low-pressure male shaft seal assembly was detected almost immediately after start-up. The power plant was connected to the ENEL electrical grid for part of the operation.

During the testing, the well began to clog. Notwithstanding the flushing with fresh water, the exhaust pipe also began to clog. The operation was stopped to clean the well and the HSE exhaust pipe.

(6) Cleaning of the Well and the HSE Exhaust Pipe:
March 12, 1982 - March 23, 1982

The well and the HSE exhaust pipe were cleaned. Some injection tests on the well were carried out to verify its condition. Preparations were made to install oil recovery lines from the special ports in the shaft seal assemblies.

(7) Completion of Performance and Demonstration Tests:
March 23, 1982 - April 1, 1982

Measured performance tests were made at various loads up to a maximum of about 450 kW and at various inlet pressures and throttle positions. Rapid scale growth in the HSE exhaust system caused elevation in the outlet pressure, a drop in machine efficiency, and stiffening of the flexible section of the exhaust pipe. The tests were stopped to clean the exhaust system. Pieces of scale more than 10-cm thick were found (Figures 7-4 and 7-5). Oil lost from the leaking seal assembly was recovered through the recapture port and sent to a holding tank for separation from the flush water. Use of the centrifuge would have been preferred but its capacity was not sufficient to handle this added load or similar loads from the other assemblies should they occur. Separation in the holding tank was poor and was aided by heating the mixture in the tank.

The testing was resumed and coupling to the ENEL grid was attempted. The coupling operation was rough, causing the shear pins in a shear coupling in the HSE power plant to shear, probably because the synchronization and coupling operation was manual. (For a discussion of the purpose of the shear coupling, see Ref. 1, p. 2-10.) New shear pins were constructed in the ENEL workshop in Larderello and then installed in the HSE so the tests could resume. Tests were then done on liquid only. After a few hours, the test was halted to permit cleaning the pipeline to the disposal well, the separator plant, the control valves and the valves near the wellhead.

After the cleaning, the power plant was operated directly from the wellhead to demonstrate the maximum producible power of 550 kW. Under this condition, the pressure drop in the pipeline and filters was about 24 psi, largely because of scale deposits. The operation was then converted to measured performance using the separators, first with liquid only, then liquid and vapor. During this test it became necessary to stop again to clean the exhaust pipe because the discharge pressure steadily increased.

The final test determined the performance of the HSE at the maximum producible power of 260 kW from the liquid phase using both separators. The separator capacity was limited by excessive entry velocity because of scale in the supply lines. The test was terminated with a check of the governor behavior at no load with liquid and vapor feed to the HSE. The check demonstrated that the power plant would idle steadily at an inlet pressure to the HSE of 180 psia if the governor were adjusted for a high droop.

All of the objectives of the HSE tests were considered reached and the plant was shut in. During the tests, the power plant produced 26.46 MWh of electricity and logged 121 test hours, of which 53 were while connected to the Italian electrical grid.

(8) Disassembly and Packing for Shipment:
April 1, 1982 - June 25, 1982

Figure 7-4. HSE Exhaust Pipe and Expansion Joint with Scale, Italy

Figure 7-5. HSE Exhaust Pipe After Hammering the Scale, Italy

The power plant and associated test equipment was disassembled and packed for shipment to New Zealand.

C. NEW ZEALAND

The tests were designed to provide data on the operation of the HSE in the two main areas of performance and endurance. Performance was monitored at two rotational speeds over a range of fluid inlet conditions and applied loads. An endurance test assessed the reliability and maintenance requirements of the equipment.

A test chronology is presented in Table C-4. The operations, beginning with the arrival of the HSE, are summarized as follows:

(1) Equipment Reception, Installation and Preparations:
September 2, 1982 - October 19, 1982

The HSE and associated equipment arrived at the site and was installed according to the process schematic shown in Figure 6-6. The instruments were calibrated and installed and the computer program was modified to suit the site and was verified. All necessary equipment repairs were done and the installation was completed and tested.

(2) Performance Tests:
October 20, 1982 - December 14, 1982

The HSE was run intermittently during the performance test period. The electrical energy generated was 36.4 MWh from 102 hours of operation. Performance testing encompassed a wide range of operating conditions in order to map the operational characteristics of the HSE. Significant improvement in the efficiency of the plant was not expected with deposition due to the low scaling potential of the Broadlands geothermal fluid. The HSE was tested at two speeds in order to assess the effect of rotor tip velocity on performance. No condensing testing was planned.

The tests were carried out under the following conditions:

Inlet pressure (psia)	100, 140, 180, 220
Inlet steam quality (%)	0, 10, 25, 50, 100
Exhaust pressure	atmospheric pressure
Electrical load (kW)	to 850
Electrical frequency (Hz)	50 ± .4
Male rotor speed (rpm)	2500, 3333

The plant was preheated for 30 to 60 minutes before being brought up to speed and exciting the alternator. In Italy a shaft sealing problem continued following the replacement of the male low-pressure shaft seal assembly. This fault taxed the oil/water separation centrifuge beyond its capacity during the New Zealand performance tests until a replacement seal assembly was installed in February 1983 prior to the endurance test.

The voltage regulator on the HSE alternator malfunctioned in November 1982 and testing ceased on November 12 until a replacement regulator was installed on November 29. During the test interruption, the 2500-rpm gear set was installed. The regulator malfunction cut short the testing at 3333 rpm, resulting in the 3333-rpm data being incomplete for an inlet pressure of 180 psia and a 10% steam quality.

Data logging during the performance tests was performed at the discretion of the computer operator, who ensured that the plant and process conditions were stable before logging data.

(3) Endurance Test Preparations:
February 6, 1983 - February 23, 1983

Preparations were made for the endurance test. The preparations consisted principally of (1) replacing the male low-pressure seal assembly, (2) modifying the piping for the centrifuge and shaft seal flush water, (3) installing a diatomaceous earth water filtration plant, and (4) reinstalling the gear set for testing at 3333 rpm.

During the replacement of the shaft seal assembly, it was discovered that a flake of extraneous material had lodged under the side face of one of the carbon seal segments, causing the oil leakage observed after installation in Italy. The flake had spalled from an imperfection in the face of the housing, evidently during the assembly or installation of the seals in Italy. This explains why the leakage was immediate and persistent. Inspection also revealed an accumulation of light-colored particulates throughout the seal assembly, including on the races. At the time of the inspection, these particulates were identified as pumice from the river. Two types of wear damage were also seen. The races under the hydraload seals were grooved, and pumice was found under the seals, although the seals themselves appeared to be undamaged. The race under the bushing seal was not damaged, but the carbon was; carbon was easily wiped off the sealing face. Because the same water supply fed all four seal assemblies, it is reasonable to assume that similar pumice loading occurred in the other three assemblies, but they were not inspected or cleaned. A possible alternative to damage by pumice or other particulates from the river exists. This alternative is damage by particulates left behind after the grinding or drilling done in the HSE case during the installation of the oil recovery passages in Italy. The cause of damage observed in New Zealand after 98 hours of operation in Italy and 102 hours of operation in New Zealand must be rationalized with the absence of detectable wear in the three seal assemblies which were removed in Italy after 1224 hours of prior operation.

The discovery of both pumice and seal damage from wear led to the installation of the diatomaceous earth water filtration plant. It should be noted that diatomaceous earth filters were used with success in Mexico to protect the shaft seals from damage by dirt in the water supply during most of the 1100 hours of operation there; subsequent inspection of three of the seal assemblies in Italy showed no sign of seal or race wear.

(4) Endurance Test:
February 4, 1983 - May 3, 1983

The endurance test was terminated ahead of schedule on the 69th day because of excessive shaft seal oil leakage. A 90-day test had been planned. The cause of the shaft seal leakage was not determined.

The electrical energy generated was 1.3 GWh from 1632.7 hours of operation of which for 1534 hours the operation was run continuously during the test. The plant was automatically shut down on March 4 by the safety shutdown circuitry when the overspeed switch tripped. The switch was reset and the test continued.

The plant operating conditions were selected to ensure that stable governor speed control could be maintained in the event of electrical load or inlet pressure variations.

The operating conditions were as follows:

Inlet pressure (psia)	177 to 182
Inlet quality (%)	25 to 27.3
Exhaust pressure	atmospheric
Electrical load (kW)	802 to 812
Throttle position (%)	47 to 61
Isentropic efficiency (%) (Calculated)	43 to 46.5

The HSE was designed as a wellhead generating unit. Under these conditions the plant must be capable of running unattended. Consequently the test was set up to run with a minimum of operator supervision.

Plant checks were performed hourly for the first three days of the test. The interval between checks was then increased until checks were performed daily at 8:00 and 14:00 hours during the working week and once every 24 hours on weekends and holidays. A plant check once every 24 hours was considered adequate for this unit.

A performance record of the plant was logged hourly by the computer during the endurance test.

(5) Inspection, Disassembly, Packing and Shipment:
May 4, 1983 - June 16, 1983

The separator plant was dismantled and returned to NZED Wairakei. A post-test inspection of the HSE was made to determine the extent of scale build-up on the rotors and housing. The power plant and associated test equipment were disassembled from the process installation, packed, and transported to Auckland for shipment to the USA.

SECTION VIII

TEST RESULTS

A. MEXICO

The computer program used for logging the test data and for calculating the test results on-line during the testing in Cerro Prieto was based on a computer program developed for the Utah tests. The Utah program contained a subroutine for the thermodynamic properties of the geothermal fluids using the steam table data of Keenan and Keyes, with corrections for noncondensable gases, and salts up to a concentration of 10%. Neither this subroutine nor the thermodynamic corrections were used in the CFE program. Instead, curve-fit approximations to steam table data were used, with no corrections for impurities. For Cerro Prieto well M-11 fluids, the corrections were deemed by CFE to be unimportant, due to the low concentration of salts and noncondensable gases (Table A-1). The operating computer program used on-line during the testing was not always updated with refinements in calibration data or flow measurement parameters during the testing, but deferring these revisions until later did not impair the use of the program for data logging or test management. CFE changed some of the nomenclature used in the computer program, thus making the nomenclature different from the nomenclature used at the other sites, as shown in Table A-3.

Site conditions at Cerro Prieto well M-11 were severe and no attempt was made to operate the power plant unattended. Ambient temperatures to 120°F and above caused electrical control devices to deform and/or to experience unexpected overload. Corrosion of electrical and mechanical equipment was a serious problem. The heavy particulate burden in the water supply for the shaft seals required close attention to and maintenance of the seal water system, and scale deposits from the brine required frequent checking and maintenance of some of the process instruments and process equipment.

(1) Endurance Test

The endurance test was run intermittently from May 31, 1980, to July 29, 1980. During the test, the power plant was operated at the maximum power sustainable by the well. The full load testing was concluded to repeat earlier performance tests at various loads and inlet pressures.

The operating conditions were as follows:

Inlet pressure (psia)	173 to 197
Inlet quality (%)	20 to 35
Exhaust pressure (psia)	15.0 to 16.1
Electrical load (kW)	807 to 882
Throttle position (%)	60 to 78
Isentropic efficiency (%) (Calculated)	50 to 59

The endurance test produced approximately 825 MWh of electrical energy generated during 978 hours of operation. The test was interrupted six times for periods of from 2-1/2 hours to six days for a total time of approximately 430 hours. None of the six stops were automatic and none were attributable to the power plant. One stop was precautionary during an earthquake and two were because of unstable wellhead pressure; the other three were failure of a rupture disc, a leak in a pressure gauge line on the supply pipe from the well, and failure of a load bank fan. These failures are chronicled in more detail in Table A-4.

(2) Endurance Test Results

A record of the process and plant performances was logged at intervals by the computer during the endurance test. A table of data from the record is presented in Table A-5. Daily averages of machine efficiency (Rm), total mass flow rate (Wt), and inlet enthalpy (He) are plotted in Figure A-4. It was predicted that the efficiency of the HSE would improve with scale deposition during the test. In earlier tests, it had been observed that the machine was internally self-cleaning, especially during test interruption. It was expected that the endurance test would offer the first good opportunity for scale growth within the machine and resulting efficiency improvement, because the endurance run was scheduled to run nonstop.

An efficiency increase was recorded during the test, as shown in Figure A-4 and Table A-5. This increase was attributed to scale growth within the machine, which reduced the clearances between the helical screw rotors and the case. For the overall duration of the test, CFE reported an increase in efficiency on the order of 4 percentage points, based on the daily averages as shown in Figure A-4. During the test, efficiency improvements as much as a 7 percentage-point daily average were shown (Figure A-4 and Table A-5). It is possible that these higher, mid-test gains were subsequently cancelled by the observed loss of scale, as was believed at the time. Or there may have been flow measurement errors, as proposed by CFE, although none were identified.

(3) Performance Tests

The performance testing was done in three groups. The first group were atmosphere exhaust pressure tests done at 3000-rpm male rotor speed before the endurance test, using the noncondensing test arrangement shown in Figure 6-1. The second group were atmospheric and elevated exhaust pressure tests done at 3000- and 4000-rpm male rotor speeds beginning immediately after the endurance test, still using the noncondensing test arrangement. The third group were atmospheric and subatmospheric exhaust pressure tests done at both rotor speeds using the test arrangement shown in Figure 6-2. The second group of tests was halted because of damage to the HSE timing gears due to blockage in a lubrication passage; this lubrication passage was part of the lubrication system blocked by insects in Utah (Ref. 1, pp. 6-15 and 6-16), and the blockage material looked similar, suggesting incomplete cleaning of the insect material. Repair of the damage and conversion of the process installation were done concurrently in preparation for the third group of performance tests.

(4) Performance Test Results

The second and third performance tests were analyzed independently and will be referred to as the "downstream test" and the "upstream test," respectively, due to the test arrangements used. The test data from the first test or group were not considered valid for this evaluation, because the preparation of the computer program and the instruments was not completed until just prior to the start of the endurance test. The endurance test was analyzed with the downstream test. The downstream and upstream tests were analyzed independently because the different test arrangements required different equations, although this should not affect the results.*

(a) Atmospheric Exhaust Pressure

Table A-6 gives a summary of the most important measured and calculated results under stabilized conditions. The results are also presented graphically in Figures A-5 through A-16.

Figures A-5 and A-6 refer to the downstream test with rotor speeds of 3000 and 4000 rpm, respectively. All the inlet conditions are included. Figures A-7 and A-8 correspond to the upstream test under speed and inlet conditions similar to those of the downstream test. These figures show a trend for the machine efficiency to increase with increasing load.

Figures A-9 to A-13 correspond to the 3000-rpm downstream test. The effect of inlet pressure and quality on the machine efficiency is observed. In Figures A-9 and A-10, the inlet pressure varies as shown for inlet quality within 10% to 20% and 20% to 30%, respectively. Although the data for each pressure do not cover the complete range of shaft output power, a slight decrease in the machine efficiency occurs with increasing inlet pressure.

In Figures A-11, A-12, and A-13, inlet quality varies while inlet pressure is kept at approximately 100, 140, and 180 psia, respectively. A slight efficiency increase is observed for the lower-quality range of 10% to 20% at pressures of 100 and 140

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* Another independent analysis of the downstream test was reported in Ref. 1. The same test data were used, but the calculations and use of the calibration data differed in some details. The efficiencies calculated in the reference tended to be somewhat lower than those reported here.

psia. At the inlet pressure of 180 psia there were not sufficient data to differentiate changes in the machine efficiency at different quality ranges.

Figures A-14 and A-15, which correspond to downstream and upstream tests, respectively, show the machine efficiency at male rotor speeds of 3000 and 4000 rpm for all inlet conditions. For the downstream test, the efficiency observed at 3000 rpm was greater than at 4000 rpm at shaft output power below 400 kW. Above that power, the difference between the efficiencies obtained for each speed is nil (Figure A-14). In contrast, the performance of the machine in the upstream test is similar for both speeds at all machine loads tested (Figure A-15).

Finally, Figure A-16 shows the efficiencies obtained during the downstream and upstream tests for all inlet conditions tested. A difference is observed between the downstream and upstream test results, especially at the lower loads, with the downstream test showing the larger efficiency.

From an analysis of flowrate information, CFE has concluded that the difference between efficiencies shown in Figure A-16 is not real, but instead is the result of error in flow measurements for the downstream test. This conclusion is based on differences in the total well output flowrates through the machine, measured during maximum load tests of the HSE using the two test installations, and comparing these rates with the total well output rates measured at other times when the HSE was not being tested. During these measurements the wellhead pressure was approximately the same. The relevant HSE test data are summarized as follows:

TEST	DATE	SPEED OF MALE ROTOR rpm	TOTAL FLOW RATE tons/h
Endurance	05/31/80 - 07/29/80	3000	45.0
Downstream	08/15/80	3000	43.0
Upstream	02/05/81	4000	54.6
Upstream	02/20/81	3000	54.0

The flowrates for the downstream and upstream tests are seen to differ by approximately 10 tons/h. The possibility that this discrepancy could be caused by a change in the production of well M-11 in the period spanned by the tests has been discounted by CFE, since the well is normally quite stable, as demonstrated by its 1979 and 1980 production characteristic curves (Figure A-3), so the discrepancy is attributed to errors in flowrate measurement.

Because the well production measured before and after the endurance test agreed more closely with the upstream values obtained than with the downstream values (Figure A-17), the errors are ascribed to the downstream measurements. The measurement procedures, namely steam flow by orifice and water flow by weir, the hardware, and the calculations were examined by CFE and found to be satisfactory. This led CFE to conclude that the only possible cause of error was inaccurate zero adjustment of the instruments during the downstream test.

The viewpoint of the author of this report is that the flowrate measurements and test results for the downstream test are probably correct, and that the flowrate of the well was different from normal during these tests. The reasons for this viewpoint are instrument details, observed well variation, compatibility of test results, and effects of scale, as discussed next:

(i) Instrument Details

The instruments for measuring the steam and water were carefully installed, calibrated and adjusted for zero flow. The zeros were routinely checked before and after testing, and the zero flow readings and calculated flowrates were normally logged by the computer. Zero errors corresponding to 10 tons/h would have been large and should have been easy to detect. The instrument transducers had been used earlier in Utah and were used subsequently in the upstream test in Mexico and in the tests in New Zealand with no significant drift. A drift of the steam transducer output in the downstream test in Mexico causing a signal shift of 0.003 V was recorded during one instrument check, but this corresponded to only 0.15-in. water differential pressure, and was corrected. This offset was insignificant compared with the differential across the orifice during the endurance test of about 28 in. of water for maximum flow.

Part way through the endurance test, the precision of the flow measurements was improved by recalibrating the steam transducer to a span of 0 to 40 in. instead of 0 to 100 in. on June 12, 1980, and replacing the water transducer having an 18-in. minimum span with a new one calibrated for 0 to 5 in. prior to the July 2nd test resumption. The zeros were adjusted and checked on-line. This work took place during the shutdowns between June 8 and June 14, 1980, and between June 26 and July 2, 1980, respectively, as shown in Figure A-4 and Table A-5. (The cleaning of the pressure control valve and the modification of the value and its installation, as discussed earlier, were done during the latter time period.) The flow data before and after these changes are in good agreement, suggesting that there were no zero errors that could explain the flowrate discrepancy of 10 tons/h compared with normal well flow.

(ii) Well Variation

Although well M-11 may be normally stable, it is known that pressure and flow instability did occur during the testing period. The endurance test was interrupted on June 8 by an earthquake of magnitude 6.7 on the Richter scale which altered the characteristics of the well, as shown in Figure A-4. The enthalpy decreased by approximately 7%, while the total flow increased in the same proportion. The endurance test was also interrupted on June 26 by variations in the wellhead pressure and on July 15 by high wellhead pressure, as reported in Table A-4. If and how the flowrate dilemma is related to the earthquake or other crustal instability during this time is not known. It is known that the ground cracked about 140 paces from the well during the earthquake and that many well cellars and ground areas were flooded from below.

(iii) Compatibility of Test Results

Based on the results of testing in Utah, a machine efficiency of 48% to 50% was predicted by the JPL Technical Specialist for the beginning of the endurance test, when the rotors were nearly free of scale.

At the beginning of the endurance test in Mexico, on May 31, 1980, the machine efficiency was determined to be 50%, using flowrates measured downstream (Table A-5 and Figure A-4). At that time the instruments had been recently calibrated and checked. Later, on February 20, 1981, during the upstream test with approximately the same test conditions, the efficiency was determined to be 48% to 49% (Table A-6 and Figure A-5). The disagreement of only 1 to 2 percentage points is significantly less than the disagreement between the downstream test results after the endurance test and the upstream test results shown in Figure A-16. The small difference in efficiencies could result from unequal scale deposit thicknesses within the machine for the two tests. The close agreement is not compatible with a flowrate measurement error of 10 tons/h. If, however, it were assumed there is a flowrate error, correcting either the water flow or the steam flow by the total estimated error impairs the compatibility of the results. Increasing the water rate by the estimated error gives a machine efficiency of 53%, which is too high for the amount of scale observed on the rotors at that time. A corresponding increase in the steam flow gives 34%, which is much too low and is not correct. The alternative explanation of a balanced sharing of the error, if it exists, is not plausible, because the error would have had to be split in approximately constant proportion every time the orifice or weir transducer was recalibrated, replaced, zeroed, or otherwise changed during downstream testing.

(iv) Effects of Scale

The disagreement between the downstream and upstream test results (see Figure A-16) can be explained by the effects of scale on the rotors. The highest efficiencies were determined at reduced power in the morning of the termination of the endurance test (see Table A-6). At that time there had been little opportunity for the machine to lose scale accumulated during the endurance test, although the machine was stopped unintentionally for a few minutes while reducing the load for the performance testing. After about 4-1/2 hours of performance testing the test was interrupted for 17 days because of damage to the load bank. There is no quantitative information about how much scale was lost during this test interruption, but it is known that some scale was lost. The subsequent performance level for the downstream test was lowered, but not down to the level measured at the beginning of the endurance test, when there was very little scale within the machine.

As a general point it should be noted that the variation of scale within the machine and the random variation of other test conditions in Mexico made determination of the HSE performance characteristics from the test data very difficult. Deposition or loss of scale changed the internal dimensions, and the performance of the machine did not remain the same. As an example, compare Figures A-14 and A-15 showing the effect of rotor speed on machine efficiency for downstream and upstream tests, respectively. The 3000-rpm downstream tests were made after the endurance test during which most of the scale was deposited within the machine. The highest efficiencies were those measured first after the termination of the endurance test. The 4000-rpm tests were made one month later after an extended period of shutdown and observed loss of scale. By comparison, the 3000-rpm and 4000-rpm upstream tests were all made about six months later. It can be assumed that by this time the amount of scale had stabilized, in agreement with observations. It should be noted that all performance testing was intermittent, being carried out on a daytime basis only, in contrast with the endurance test. From these facts it is the view of this author that much of the spread of data seen for the downstream tests in Figure A-14 was caused by effects of scale rather than rotor speed, especially when compared with Figure A-15. The same difficulty with the effects of scale applies to the interpretation of all of the HSE test data at well M-11. The author believes the difference in efficiencies between the downstream and upstream tests shown in Figure A-5 can be similarly explained.

(b) Above Atmospheric Exhaust Pressure

Part of the downstream test was conducted with exhaust pressures greater than atmospheric pressure. The process arrangement was as shown in Figure 6-1, except for the addition of a variable orifice plate placed at the HSE outlet (Ref. 1, pp. 5-27 and 5-29).

The operating conditions were as follows:

Inlet pressure (psia)	100, 140 and 180
Inlet quality (%)	27 to 35
Exhaust pressure (psia)	24 to 41
Male rotor speed (rpm)	3000 and 4000
Electric load (kW)	211 to 472

A summary of the test data is presented in Table A-7.

An increase in the exhaust pressure had a negative effect on the machine efficiency, as shown in the following representative results:

Exhaust pressure (psia)	14.95	31.80
Date	08/28/80	08/27/80
Time	10:26:59	10:43:47
Rotor speed (rpm)	4000	4000
Wellhead pressure (psia)	276.2	196.9
Inlet pressure (psia)	138.0	143.0
Inlet quality (%)	20	27
Electric load (kW)	271	288
Total flow rate (lb/h)	57599	85599
Isentropic efficiency (%) (calc.)	43.6	35.0
Specific flow rate (lb/kWh)	212.4	297.2

The specific total mass flowrate increases with the increase in the back pressure due to the reduction of available energy as the exhaust pressure increases and to the lower isentropic efficiency obtained.

The test results are limited and only the effect of rotor speed on machine efficiency can be evaluated. The efficiency at 3000 rpm was greater than at 4000 rpm, as shown in Table A-8.

(c) Subatmospheric Exhaust Pressure

Tests with subatmospheric exhaust pressure were conducted as part of the upstream, or third, performance test. The operating conditions were:

Inlet pressure (psia)	100, 140 and 180
Inlet quality (%)	11 to 24
Exhaust pressure (psia)	3.05 to 12.76
Electrical load (kW)	265 to 745
Rotor speed (rpm)	3000 and 4000

The results of these tests are considered to be preliminary because the test arrangement was adapted from the existing installation and was not optimum. The cyclonic separator previously used at the HSE outlet to measure steam and water flowrates was adapted for use as a direct-contact condenser, as shown in Figure 6-2. Waste brine from the evaporation pond was used as cooling water. The water and steam flow measurements were made upstream from the HSE.

The pumping equipment that was installed to handle the cooling water and the discharge from the condenser was not suitable for efficient operation. The water supply pumps did not have sufficient capacity and high vacuum was achieved only at low loads. The pump to extract the condensate did not operate properly for the different work needs, and instability in the water level in the condenser was observed on different occasions.

The results for the subatmospheric exhaust pressure tests are summarized in Table A-9. Average results for each condition are shown in Table A-10 and are compared with tests at atmospheric exhaust in Table A-11.

The machine efficiency decreases when the inlet pressure increases (Table A-10, lines 4 and 6, and 12 and 15), in agreement with the results obtained from atmospheric pressure tests. The machine efficiency also decreases when greater exhaust vacuum is achieved (Table A-10, lines 7, 8 and 13, and Table 9). This is counter to the trend seen when comparing atmospheric exhaust pressure and above atmospheric exhaust pressure.

In regard to the effect of rotor speed, no clear difference in the efficiencies was observed (Table A-10, lines 1, 7 and 8, and 4 and 16), in general agreement with the atmospheric discharge tests.

It is important to observe that subatmospheric exhaust pressure produced a reduction in the specific total mass flowrate in every case, despite a reduction in machine efficiency (Table A-11), due to the additional energy available from the fluid while passing from atmospheric to subatmospheric pressure. The benefit is more pronounced with lower backpressure. However, the required energy to obtain condensation, and the steam flow in the ejector, were not considered.

(5) Conclusions

(a) The use of the HSE is entirely feasible, based on the operating behavior. This is supported by the operational indexes and the distribution of failures during the tests.

(b) The isentropic efficiency of the machine improves as the shaft output power increases.

(c) At constant inlet quality, the machine efficiency decreases slightly as the inlet pressure increases.

(d) The effect of rotor speed on the machine efficiency is not important when the HSE operates at atmospheric and subatmospheric exhaust pressure. With above atmospheric exhaust pressure, an increase in the isentropic efficiency is observed for 3000 rpm.

(e) With discharge pressures above and below atmospheric pressure, the isentropic efficiency is less than that obtained during the atmospheric discharge tests. As the discharge pressure decreases, the specific flowrate (lb/kWh) decreases.

(f) An increase in the machine efficiency observed during the endurance test is attributed to the effect of scaling within the HSE.

(g) The author of this report concludes that variations of scale thickness within the HSE at different times caused variations in the machine performance and made the determination of performance characteristics difficult.

B. ITALY

(1) Performance Testing

The computer program used for logging the test data and for calculating the test results on-line during the testing was based on the computer program developed for the Utah tests. The Utah computer program contained thermodynamic corrections that were valid for salt concentrations in the brine from 0% to 10%, but not for the Cesano 1 salt concentration of 31%. The adaptation of the Utah program for the Cesano 1 HSE tests was satisfactory for logging the test data and monitoring the tests, but was not intended for calculating the efficiency of the HSE as determined by these tests. For this purpose it was necessary to determine the thermodynamic properties of the brine and to apply these properties in the program as corrections to the thermodynamic properties of steam and water that were included as part of the Utah computer program. The thermodynamic properties of the brine determined for the purpose consisted of enthalpy of liquid brine, vapor enthalpy, CO_2 enthalpy, mixture enthalpy, vapor pressure of brine, brine density, brine entropy, CO_2 entropy, and mixture entropy, all treated in Ref. 8, where the application to the efficiency calculation procedure is also discussed. The discussion includes an assessment of the test instrumentation reliability and a sensitivity analysis of the uncertainty of critical process parameters, showing the effects on the calculated efficiency.

(2) Performance Test Results

The performance test results are shown in Table B-4 listed as unprocessed data. The tabulation includes the data cassette file numbers. These test results include data that were averaged by the computer before being recorded and data recorded as a series of instantaneous measurements.

The recorded data of Table B-4 were examined and 18 experimental points were selected. The data for the 18 experimental points were then averaged and the results presented as shown in Table B-5 and Figure B-1. The results are in good agreement with the test results for Utah, for which correlation functions f_w, g_p and g_Q were derived (see Table B-6). These correlation functions were applied to the test results of Table B-4 to calculate the modified efficiency η^* reported in the table, where

$$\eta^* = \frac{\eta \times 10}{f_w \cdot g_p \cdot g_Q}$$

and η = eff %.

A perfect correlation of the results would yield values of modified efficiency η^* equal to 10.00, whereas the average value in Table B-5 is 10.29, or 2.9% higher.

An efficiency correlation equal to $\eta/f_w g_p g_Q$, or $\eta^*/10$, was plotted versus shaft output power, shown in Figure B-2, and versus throttle position, shown in Figure B-3, as was done previously with the Utah data (Ref. 1). Both plots show values of $\eta/f_w g_p g_Q$ that center about unity. This implies that the correlation is valid, as seen by comparing Figures B-1 and B-2, and that the HSE efficiency is independent of throttle position, as seen in Figure B-3. The spread of the data from unity results both from limitations of the data correlation functions as presently developed and from experimental data scatter.

(3) Conclusions

The HSE efficiency is independent of throttle position, as shown in Figure B-3, but this is not obvious by a cursory inspection of the test data. However, closer examination reveals that throttle position is not an independent variable but, as expected, is related to inlet pressure, inlet quality, load, and perhaps other variables.

If the influence of inlet pressure (or pressure ratio), inlet quality, and load are normalized by the correlation technique of Ref. 1, the dependent and independent variables are identified or separated.

From Figure B-1 it is evident that at shaft loads above 250 kW, the HSE efficiency can be taken as 45%, the same as for the Utah results (Ref. 1). After the compatibility of the Cesano and Utah data was established and applicability of the previous correlation analysis was confirmed, further analysis and interpretation of the data was attempted (Ref. B). For this purpose a theoretical model of the HSE operations was developed treating the machine as positive displacement with a given inlet volumetric flowrate and a built-in expansion ratio, and taking into account fluid entry and exit considerations. For this analysis, the Utah and Mexico test data from Ref. 1 were used, along with the Cesano data, as far more data are available from these earlier tests, and in these tests no problems were encountered in determining the thermodynamic characteristics of the brines.

For the data examined with the aid of the theoretical model, the HSE efficiency increases logarithmically with shaft power. Inlet quality or pressure ratio between inlet and outlet seem to have no appreciable influence on the trend of efficiency calculated from the model. Despite all approximations, the analysis was reported to indicate that the low apparent efficiency, at reduced loads, is due to increased influence of power loss from leakage and friction when there is a decrease in shaft power. Considering the overall power loss involved, one may assume that leakage is responsible for much of this loss; this hypothesis also seems to be confirmed by the large clearances between each of the rotors and between the rotors and the casing.

Within the validity limits of the analysis it was concluded that the efficiency limit of the machine ranges between 65% and 68%. In order to reach these values, the pressure losses through the throttle valve and at the outlet must be reduced to zero, which could be achieved with reasonable approximation by regulating the flowrate of the geothermal fluid and/or the rotational velocity of the HSE, according to the thermodynamic characteristics of the fluid. The analysis and the interpretation were considered to be tentative (see Ref. B).

C. NEW ZEALAND

(1) Performance Testing

The computer program used for analyzing the New Zealand test data was based on the program developed for the Utah tests but with modifications to the steam and liquid flowrate equations and to the gear box and the alternator power loss equations. Details of the changes made to the computer program are given in the performance calculation procedure (Table C-5). Computer outputs selected for tabulation of results are identified in a list of variables (Table C-6).

All the data were analyzed with 0 ppm total dissolved solids and 0% gas in the steam. A sensitivity analysis was undertaken using 5000 ppm total dissolved solids and 2.5% gas by weight in the steam, which were representative of the test conditions. The isentropic efficiency varied by 0.3% in the worst case, and, hence, the dissolved solids and gas content are not accounted for in the tabulated data.

(2) Performance Test Results

The inlet pressures at which the performance tests were conducted were selected so that comparisons with the data generated from the Mexican tests at Cerro Prieto could be made. The performance test results are presented in Table C-7 and Figures C-3 through C-19. Figures C-18 and C-19 define the stability envelopes for the 3333-rpm and 2500-rpm data. The maximum inlet pressure at which the governor could maintain stable operation of the plant with the HSE equipped with the low-pressure inlet trim was found to be 220 psia for all-liquid feed, but stable operation at 220 psia could not be maintained on all-steam feed. With the low-pressure inlet trim, the plant will idle over the lower range of operating inlet pressures only. The maximum inlet pressure at which the plant could idle with this trim was not accurately defined, but it is thought to lie between 120 psia and 140 psia.

The following trends are evident from the graphs contained in Appendix C:

(a) From the data with an inlet steam quality of 10% or greater, Figures C-3 to C-6:

  (i) The isentropic efficiency of the HSE increases with increasing shaft power for a given rotational speed and inlet pressure.

  (ii) The isentropic efficiency of the HSE decreases with increasing inlet pressure for a constant load and rotational speed.

(b) For the all-liquid case, Figures C-7 and C-8, the isentropic efficiency is observed to peak and then decline with increasing load for a fixed rotational speed and inlet pressure.

(c) The isentropic efficiency increases with increasing inlet steam qualities between 0% and 10% and then decreases as the inlet steam quality further increases from 25% to 100% for a fixed load and inlet pressure (Figures C-9 and C-14).

(d) Trends evident from the 2500-rpm and 3333-rpm data indicate the 2500-rpm speed is slightly more efficient than the 3333-rpm speed for loads less than 400 kW whereas the 3333-rpm speed of operation is more efficient for loads greater than 400 kW (see Figures C-15, C-16 and C-17). When treated two-dimensionally, the data scatter spans a broad band but least squares quadratic curves generated from the data indicate the same trend with the curves intersecting at 385 kW.

(3) Endurance Test

The endurance test was run from February 24, 1983, to May 3, 1983. The test was terminated ahead of schedule because of excessive shaft seal oil leakage.

From 1632.7 hours of operation, 1.3 GWh of electrical energy were generated. The operation ran continuously for 1534 hours during the test. On March 4 the plant was shut down automatically by the safety shutdown circuitry. The switch setting was reset and the test resumed.

The plant operating conditions were selected to ensure that stable governor speed control could be maintained in the event of electrical load or inlet pressure variations.

The operating conditions were as follows:

Inlet pressure (psia)	177 to 182
Inlet quality (%)	25 to 27.3
Exhaust pressure	atmospheric
Electrical load (kW)	802 to 812
Throttle position (%)	47 to 61
Isentropic efficiency (%) (Calculated)	43 to 46.5

The HSE was designed as a wellhead generating unit. Under these conditions the plant must be capable of running unattended. Consequently, the test was set up to run with a minimum of operator supervision.

Plant checks were performed hourly for the first three days of the test. The interval between checks was then increased until checks were performed daily at 8:00 and 14:00 hours during the working week and once every 24 hours on weekends and holidays. A plant check once every 24 hours was considered adequate for this unit.

(4) Endurance Test Results

A performance record of the plant was logged hourly by the computer during the endurance test. A tabulation of data that were logged at four-hour intervals is included in Table C-8. A 3.5 percentage-point improvement in the HSE efficiency was observed during the endurance test as scale built up on the internal surfaces of the machine. At the conclusion the efficiency was 46.5% and evidently still increasing. The post-test inspection of the rotors and the housing determined the extent of the scale build-up. The deposition on the rotors was observed to be a very thin, glassy layer, while that on the housing was observed to be 0.13-mm thick increasing to

1.0 mm in the exhaust elbow. The depth of the scale on the rotors was insignificant in comparison with the 1.3-mm deep hard facing on the rotor tips.

(5) Conclusions

The least squares quadratic curves generated from the New Zealand test data defined the isentropic efficiency of the HSE to be approximately 40% at loads greater than half full load when operating on low-scaling geothermal fluids. This efficiency is lower than was reported for the previous three test sites. The reason for the differences is not known.

The design philosophy of providing abnormally large internal clearances within the HSE to accommodate severe scaling was not properly tested because of the low-scaling potential of the Broadlands geothermal fluid, but trends observed during the endurance test indicate that the efficiency of the HSE does increase with adherent internal scale formation. A 3.5 percentage-point improvement in the isentropic efficiency of the HSE was observed over the 1632 hours of operation during the endurance test.

Slightly superior performance was observed at the 3333-rpm male rotor speed than was observed at the 2500-rpm male rotor speed for loads greater than half full load.

The HSE can be run on an unattended basis, as was the case during the endurance test, with daily plant checks and maintenance performed as necessary.

Plant operators need to be trained to operate and maintain the HSE, but the operation of the plant is no more complex than any other form of small turbine generating plant. Modifications to the governor system should be made to enable the plant to idle across the full range of operating pressures.

Plant reliability is of the utmost importance in the selection of small geothermal generators.

SECTION IX

SCALING AND DETERIORATION

A. MEXICO

Although a detailed program was not established to determine the effects of scaling of the system, some observations were made during the different test periods.

(1) At opportune times, the rotors were inspected for scale within the HSE through two 31.8-mm (1.25-in.) inspection ports in the case near the high-pressure end. The inside of the machine was essentially free of scale at the beginning of the tests. Some scale formed during the tests but inside the machine all scaling was relatively soft and easily detached. The patchy appearance of the scale indicated that detachment occurred during running or while stopping or both. Loss of scale also occurred during periods while the machine was stopped. The reasons for the loss of scale are not known, but temperature changes, exposure to air, drying, and surface bond may all be factors. No information is available on the amount of the scale on the rotors associated with each test.

(2) The largest observed scale thickness on the HSE rotors was produced during the endurance test.

(3) At the end of the endurance test the rotors were inspected. Scale deposits were observed but the thickness was not measured.

(4) The maximum deposit of record on the rotors was 0.020 in. measured on the female rotor near the hard tips on August 11, 1980. The measurement was by HPC and witnessed by JPL during the second performance test period while the test was interrupted for repair of a load bank fan. A uniform layer of the thickness measured would have closed the leakage passages by at most 40%, but the scale was observed to be patchy. No uniform layer of scale deposit from M-11 brine within the HSE was ever observed.

(5) The inside of the HSE was inspected at the end of the downstream and upstream performance tests with less scaling observed than at the end of the endurance test; the scale was not measured.

(6) Early in the testing, scale deposited in the pressure control valve (V-ball) located between the well and the HSE (Figure 6-1), causing the valve to stick and resulting in pressure instability. The valve was cleaned and additional grease cups and passages were installed. The operability of the valve was improved by reinstalling it in the direction opposite to that recommended by the manufacturer for normal sevice.

(7) By the end of the endurance test, a scale deposit 15 mm (0.6-in.) thick had been formed in the 152-mm (6-in.) diameter pipeline located between the pressure control valve and the HSE. The chemical composition of the scale is reported in Table A-12.

(8) After the subatmospheric exhaust pressure test, a scale deposit with thickness from 0.2 mm to 17 mm (0.008 to 0.67 in.) was observed in the 610-mm (24-in.) diameter exhaust pipeline located between the HSE and the condenser. The chemical composition of the scale deposit is reported in Table A-12.

In the flush water supply system, all the carbon steel fittings corroded internally, producing a buildup of corrosion products. CFE laboratory analysis of the corrosion products showed them to be iron sulfide, presumably caused by the hydrogen sulfide known to be in the flush water.

B. ITALY

Scale deposition from the heavy Cesano 1 brine occurred very rapidly at the lower pressures and temperatures. For example, in the HSE exhaust port and exhaust pipe, the scale growth rate of glaserite was about 2 cm/h. However, bonding to the rotors was poor and during the Cesano tests no increase in HSE efficiency due to scale growth was noted. No erosion or corrosion was reported.

During the removal of the three damaged shaft seal assemblies for repair, substantial corrosion was observed in the seal flush water passages supplying the seal assemblies. The corrosion occurred in the high-pressure end section of the housing in which two of the assemblies were installed. This section is carbon steel. The corrosion was attributed to operation in Mexico where the flush water contained hydrogen sulfide. No corrosion was detected in the low-pressure end section, which is stainless steel.

C. NEW ZEALAND

A post-test inspection of the HSE rotors and housing was made. The scale deposition on the rotors was observed to be a very thin, glassy layer, while that on the housing was observed to be 0.13-mm thick, increasing to 1.0 mm in the exhaust elbow. The depth of the scale on the rotors was insignificant in comparison with the raised, hard facing on the rotor tips. No corrosion was reported.

SECTION X

EQUIPMENT FAILURES

A. MEXICO

A log of all equipment failures was maintained for both the HSE power plant and the site installation. These are tabulated and identified in the Operation and Failure Summary (Table A-4).

Fourteen of the failures were associated with the power plant. The first three were caused by high differential pressure across the filter in the oil console. The filters that caused the problem had a manufacturer's stated 6-month shelf life, but had been stored out of doors for two years in Utah. Replacement with new filters eliminated the problem. Failure No. 4 was caused by the failure of 30-A fuses that supplied auxiliary equipment. The auxiliary load had been increased. The problem was corrected by installing 40-A fuses.

Failures Nos. 5, 6, and 7 related to the pilot-operated solenoid valves located in the hydraulic system that is associated with the safety shutdown system of the power plant. The three failures occurred because one or both of these valves failed to seat properly. This valve failure was a recurrent problem during the testing in Utah (Ref. 1, p. 7-37) and resulted from dirt in system components as received from the original equipment manufacturer. It was recommended (Ref. 1, p. 7-40) that the hydraulic system be cleaned to stop this recurrent problem, but the disassembly and cleaning were never convenient during any phase of the IEA Programme. The problem continued throughout the testing at each site, more often interfering with starting up the plant rather than with stopping the plant.

Failure No. 13, failure of the synchronization gear, was caused because of blockage of a lubrication passage. The line had been plugged by an insect in Utah during the shaft seal modification (Ref. 1, p. 6-16), and, unfortunately, the removal of the plugging material was not complete. The material migrated and plugged a nozzle for spraying oil onto the gears. Failure No. 14, variation in the voltage generated, was caused by corrosion on the contacts of one or more voltage potentiometers in the voltage regulator for the alternator. The problem was resolved by cycling the potentiometers.

From the above discussion it is seen that nine of the fourteen failures attributed to the HSE power plant are fully understood and either were or can be easily corrected. All were external to the HSE except the failure of the rotor synchronization gears. The remaining failures were also external to the HSE. These failures were easily corrected, but the causes were not as easily eliminated. Four of these failures resulted from contaminants in the water for the shaft seals and the fifth resulted from the accumulation of air in the main oil pump while the power plant was shut down.

B. ITALY

Unfamiliar harsh noises emanated from the HSE during testing on Cesano 1 fluids beginning during the first test. Vibration was associated with these noises. Vibration protection switches shut down the power plant early in the first test and it was necessary to increase the switch settings in order to continue the testing. At random intervals, sharper sounds or hits and larger vibrations were observed. The unfamiliar noises and vibrations were believed to be caused by scale that was deposited rapidly within the HSE and that broke loose into the path of the rotors. After 26 hours of operation, cumulative damage to the shaft seals resulted in excessive oil consumption. Inspection showed that some of the carbon segments in the damaged seals had each cracked at the center notch where the segment rested against a locking pin. Replacement of three of the four seal assemblies was necessary to continue the test programme. One of the replacement assemblies leaked immediately, but not severely enough to prevent completing the tests. No further segment breakage was detected.

The connecting of the power plant to the ENEL grid was done manually. While the connection was being made on March 24, 1981, the synchronization was inexact and the shear pins were broken, as discussed earlier in Section VII. During one attempt, the vibration switches were tripped. The failure of the shear pins is not considered a power plant deficiency. Neither are equipment damage or failures reported for the load bank or other auxiliary equipment.

C. NEW ZEALAND

Equipment problems were encountered during the performance test period and during the endurance test. During the peformance test period, the shaft sealing problem that followed the installation of the defective male low-pressure shaft seal assembly in Italy continued as discussed earlier. The discontinuous nature of the performance test made it impossible to determine if the leakage rate changed during the test period. A failure of the voltage regulator for the HSE alternator required stopping the performance test after 61.5 hours of test until a replacement regulator was installed. The regulator that failed had malfunctioned earlier, beginning in Mexico, where the ambient H_2S, salt spray, humidity and temperature were sometimes very high.

During the endurance test, wear and failure of several components occurred. The most significant failure involved loss of oil through the shaft seals. The seals have a design oil consumption of approximately 3.8 l (1 gal.) of oil per day per seal, on the average, at 3000-rpm male rotor speed, and perhaps 5 to 7 l per day per seal average at 3300-rpm male rotor speed. This oil migrates across the seals into the flush water and can be discharged to waste with the geothermal fluid as was done in New Zealand, or it can be recaptured from the seal assemblies through the recapture passages. At the start of the New Zealand endurance run the oil loss from the machine (four seals) was monitored to be 35 l per day, well above the design consumption. For the entire endurance tes 3750 l of oil were lost at an average oil consumption of 55 l per day for the test.

The high initial consumption and the increase can be explained if particulates of the types that damaged the low-pressure male seal assembly, which was replaced (see (3) in Section VII.C), also damaged the other three assemblies. The progressive damage during the endurance test can be explained by damage in the other three assemblies from seal races damaged by particulates during the performance test or from damage caused during the endurance test by particulates not removed from the system. The explanation of damage by particulates is supported by the inspection in Italy of three seal assemblies, which showed no detectable wear after 1224 hours of operation up to the time of removal of the seal assemblies for inspection, failure analysis and replacement.

A second possible explanation for the increase in oil loss during the endurance test is thermal distortion in the high-pressure female seal assembly caused by a blockage of the oil flow necessary to keep the seal assembly cool. This explanation is less likely because of the continuing increase after the blockage was corrected. The correct explanation for the excessive oil leakage rate may not be known until the seals in all four assemblies used during the endurance test are inspected.

Four other failures on ancillary equipment occurred:

(1) The plant was automatically shut down on March 4 by the safety shutdown circuitry when the overspeed switch tripped, as stated earlier. The switch was reset and the test continued. It is not known whether the circuitry or switch malfunctioned, or whether the switch setting drifted or was improperly set. What is known is that the characteristics of the switch made the setting of the switch imprecise but normally free of drift. Equipment purchased for setting the switch on the bench was not satisfactory so the setting of the switch was usually done while installed.

(2) The automatic greasing system ceased to function on April 7 when a microswitch failed. Greasing of the governor valve was performed manually on a daily basis for the remainder of the test because a replacement switch was not available.

(3) The two metering pumps used to scavenge water from the bottom of the oil reservoirs failed in late April. One unit ceased to rotate. The other continued to rotate but ceased to pump. One pump removed water from the main oil reservoir. Prolonged, undetected failure of this pump would result in water being fed to the bearings and shaft seals. After the failure was detected, the main oil reservoir was drained of 15 to 25 gal. of water daily. One pump was repaired just prior to the termination of the test. Both pumps were installed because of problems relating to the centrifuge. The centrifuge was installed above the main oil reservoir so that the case of the centrifuge drained into the reservoir. This was done to avoid loss of the oil flowing to the centrifuge if the centrifuge were to fail or stop. Unknown at the time of installation was that some of the water that the centrifuge removed from the oil drained into the centrifuge case and consequently into the reservoir. The second

reservoir and pump were installed to provide separation by settling because the capacity of the centrifuge was not sufficient to handle an increase in load. The preferred corrective measure would be to replace the centrifuge with one of adequate size, installed so that no water from the centrifuge drains into the main oil reservoir. Otherwise, higher quality pumps are recommended. The installation of a high-water sensor to actuate a drain valve on the reservoir is desirable in the event of pump failure.

(4) The jacking motor failed to turn the rotors upon termination of the test on May 3. The jacking motor assembly had been installed in Mexico during preparation for testing there. To avoid delaying the tests, readily available parts had been utilized. The overriding clutch assembly of the jacking motor was known to be marginal in its radial misalignment capabilities, and consequential wear caused the failure.

SECTION XI

MAINTENANCE: NEW ZEALAND SITE

During the endurance test, the following maintenance was performed on the HSE:

(1) 3750 l of Caltex Regal R + O 46 turbine oil were added to the oil reservoir.

(2) The 25-μm main oil filters were changed five times.

(3) The 5-μm shaft seal oil filter was changed once.

(4) The centrifuge was cleaned three times.

(5) The oil cooler cowling was cleaned twice.

The oil usage has been discussed in the previous section. The number of main oil filter changes is significantly more than estimated by HPC. Replacement filter elements had to be brought into New Zealand from the United States. It is thought that water entrained with the oil was causing the rapid blocking of the paper elements. Polypropylene elements were tested and they exhibited superior performance. Since a centrifuge of proper size and placement can eliminate water entrainment in the oil, frequent changes and the use of polypropylane elements instead of paper elements should not be necessary.

SECTION XII

RECOMMENDATIONS

A. MEXICO

CFE recommends that tests be designed and carried out specifically to measure the effects of scaling on the efficiency of the HSE as the internal clearances close.

B. ITALY

The following recommendations were based either on test results or general considerations:

(1) The shaft seal design was successfully improved to take into account the vibrations and mechanical shock induced from operation with scaling fluids. Additional improvement is recommended.

(2) The rotor-to-rotor and rotor-to-case clearances should be diminished in order to improve the HSE efficiency. (See also Ref. 1, p. 7-38.)

C. NEW ZEALAND

The Ministry of Works and Development recommends the following machine modifications and improvements:

(1) Shaft Sealing - Modifications to protect the shaft seals from abrasives carried by the flush water must be undertaken to improve the reliability of the HSE.

(2) Governor - Modifications to the governor system (see also Ref. 1, pp. 7-38 and 7-41) are recommended to:

   (a) Overcome rapid hunting of the governor valve. (See Section II.A.3.)

   (b) Enable the plant to idle over the full range of operating pressures. (See Section II.A.3.)

(3) Centrifuge - It is recommended that a centrifuge with increased capacity be installed. A self-cleaning centrifuge should be considered.

(4) Plant Start-Up - Excessive effort is required to open the hydraulically operated safety shutdown valve. The hand pump should be replaced with an electric pump actuated from the key start. (Also see Ref. 1, p. 7-41.)

The hydraulic control system is prone to air entrainment upstream of the battery-operated oil pump on start-up. Piping modifications and an automatic air bleed would overcome this problem.

The battery-operated oil pump could be replaced with a unit with a larger capacity and a higher delivery pressure to improve the governor response on start-up of the plant.

Larger-capacity batteries should be installed to provide sufficient capacity to power the suggested improvements in the battery-operated equipment and to allow for an extended start-up.

(5) Instrumentation - Instrumentation to display the bearing temperatures should be installed on the skid mount.

(6) Piping Modifications - An improved layout of the water and oil supply piping to the shaft seals and bearings is highly desirable to enable easier fault tracing and maintenance of these systems. (Also see Ref. 1, p. 7-41.)

D. GENERAL RECOMMENDATIONS

The author of this report recommends that:

(1) The following be performed with the HSE Power Plant Model 76-1:

- (a) Disassemble the shaft seals and analyze all components for damage.
- (b) Replace all damaged parts.
- (c) Install new shaft seal assemblies.
- (d) Install a new shaft seal support system of preferred size and components, including flush water filtration to 1 μm.
- (e) Reconvert for 60-Hz operation to restore output rating to 1 MW.
- (f) Operate under design conditions to close the rotor clearances.
- (g) Measure performance as clearances close.
- (h) Operate with useful load at least long enough to obtain service life information.
- (i) Perform a cost/benefit analysis on the results.
- (j) If benefit analysis is favorable, determine the performance under various conditions.

(2) The HSE Power Plant Model 76-1 be replaced with a new model of larger size (such as the 5-MW size replacement originally planned for the earlier project) having a compound speed control valve and all other improvements identified during testing as desirable and possible, and then test for performance and service life.

SECTION XIII

COST/BENEFIT ANALYSIS

The cost/benefit analysis for each site was guided by the following specifications from the Executive Committee:

(1) The possible applications and potential for the HSE power plant in each participating country should be reported.

(2) An economic comparison of the 1-MW Model 76-1 HSE power plant with a 1-MW back-pressure steam turbine set should be made. The cost estimates should be on the basis of commercial production of electric power, excluding geothermal well costs. The assumptions made in the analysis should be reported.

The analysis for each site was based on the HSE performance as measured, with the clearances and the leakage past the rotor assumed to remain as tested. The possibility that the efficiency gains demonstrated during the endurance tests might continue as more scale deposited during prolonged use, thus progressively reducing leakage, was not considered in the analysis. The HSE price was assumed to be the cost of Model 76-1, as used, without improvements. It should be recognized that since the Model 76-1 is a one-of-a-kind machine built for test purposes, this price may not accurately reflect what the actually quoted price would be to a prospective purchaser of a commercial HSE power plant, or what model would be available.

In the analyses, all speed reducer and alternator losses were ignored or assumed equal for comparably sized machines.

A. MEXICO

The analysis was based on a comparison of the specific total mass flowrates (tons/h per megawatt) and costs for a 1-MW HSE power plant and a 1-MW steam turbine set, both in back-pressure operation. Two sets of benefit analyses were done. The first set was for a hot-water reservoir temperature corresponding to well M-11; the second set applied to a spectrum of hot-water reservoir temperatures.

Isentropic machine efficiencies were selected on the following bases:

(1) Steam turbine efficiency of 65% for a portable, noncondensing steam turbine operating with inlet pressure ranging between 4 and 20 bars (58 and 290 psi), according to commercial literature.

(2) HSE efficiencies (η_m) of 55% and 48%, based respectively on endurance test results with flow measured downstream (Figure 6-1) and subsequent test results with flows measured upstream (Figure 6-2).

1. Benefits

a. <u>Comparison of Specific Total Mass Flowrate</u>. Figure 13-1 shows the variation of specific total mass flowrate as a function of inlet pressure for the three generator sets operating on a hot-water reservoir with a temperature

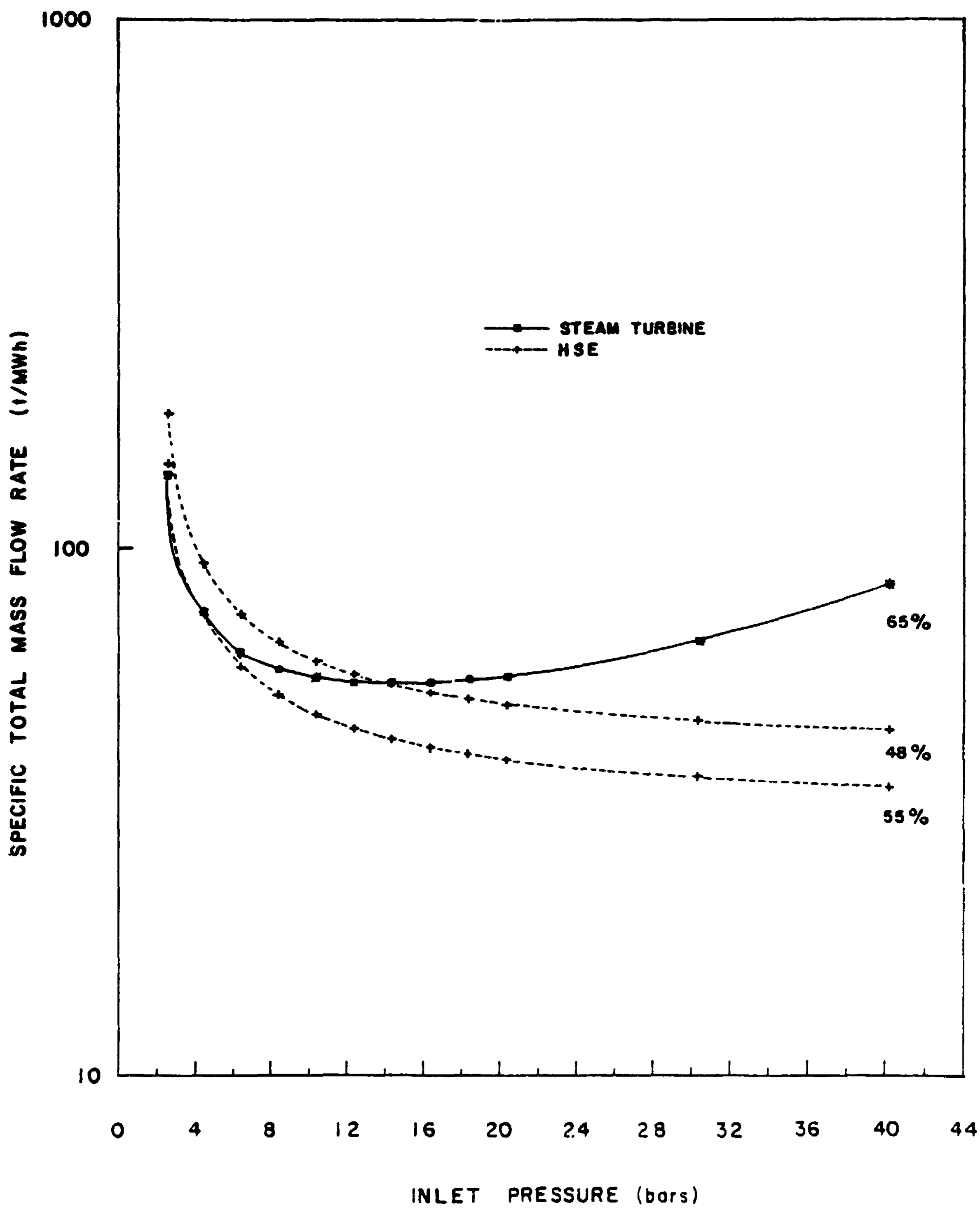


Figure 13-1. Comparison Between the HSE and a Steam Turbine; Reservoir Temperature 290°C (Ref. A, Fig. 25)

of 290°C, corresponding to well M-11. As the figure shows, the HSE with 55% efficiency is superior to the turbine for all values of inlet pressure, based on specific consumption. If the HSE efficiency is 48%, the HSE is favored only for inlet pressures above 14 bars (203 psi). However, in the case of well M-11, the HSE inlet pressure would be limited to 12 to 14 bars (174 to 203 psi) or less, since the well production decreases more rapidly than the specific total mass flowrate as pressures increase above 14 bars, as shown with the aid of the well production characteristics curve (Figure A-3).

b. Comparison of Power Generation from Well. An analysis was made for well M-43 to compare the maximum obtainable power generation using a well with similar temperature, but greater production than well M-11 where the HSE tests were performed.

Production data on well M-43 are as follows:

Pressure Bars	Flowrate tons/h
13.07	146.2
13.36	145.3
17.00	141.0
23.20	118.4

The inlet pressures used in the analyses were 14 bars for the turbine and 20 bars for the HSE, these pressures being considered as the respective optimum values. Operation of the HSE with inlet pressures as high as 20 bars was not demonstrated.

The energy and mass balance for each generator set is included in the process diagram shown in Figure 13-2. The following data were obtained:

Machine	Efficiency %	Power MW	Specific Total Mass Flowrate tons/MWh
Steam Turbine	65	2.60	55.0
HSE	48	2.65	50.6
HSE	55	3.04	44.1

The choice between installing a steam turbine of 65% efficiency or an HSE of 48% efficiency on well M-43 will depend only upon cost, if the specific total mass flowrate advantage of the HSE is not important. The fluid disposal requirements of the HSE are also smaller. These advantages could be important when an entire reservoir with a temperature of 290°C is being considered. A 55% efficient HSE is the preferred machine based on performance benefit, if the cost permits.

c. Comparison for Hot Water Resources of Other Temperatures. The analysis was extended to investigate the benefit that could be obtained with the HSE on hot water reservoirs having other temperatures, assuming the same efficiency values for the machines.

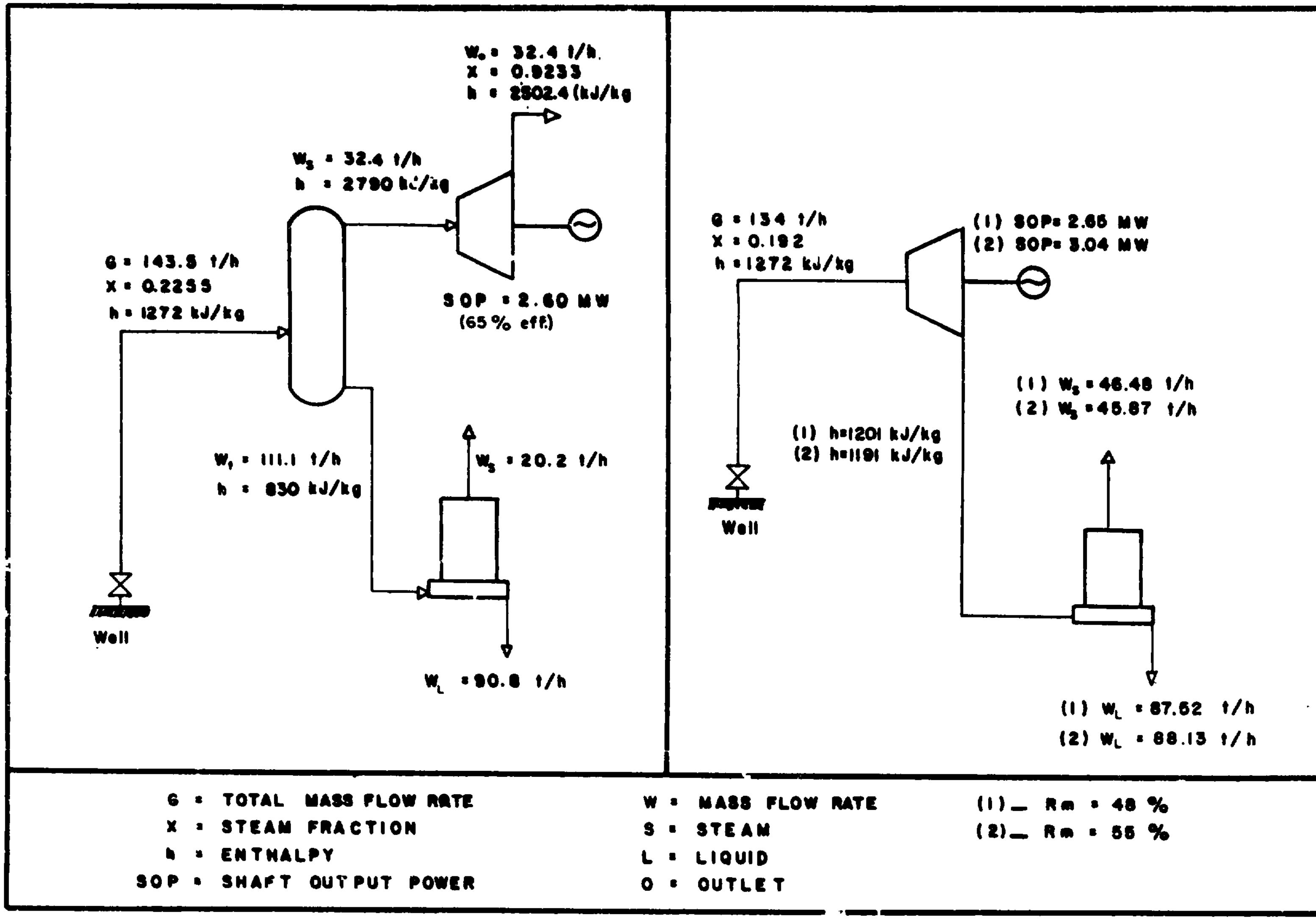


Figure 13-2. Mass and Energy Balance, Well M-43 (Ref. A, Fig. 26)

The relationship of specific total mass flowrate and inlet pressure is compared for the turbine and the 48% and 55% efficient HSEs in Figures 13-3 and 13-4, respectively, for five reservoir temperatures. The results are summarized in Table 13-1 to show the inlet pressure ranges for which the specific total mass flowrate of the HSE is less than for the steam turbine.

Although each well has a particular production behavior, it is reasonable to assume that for wellhead pressures greater than 15 to 20 bars, productivity begins to decrease rapidly with increasing pressure. With this response, available well productivity is wasted. Based on this consideration and the results in Table 13-1, it can be concluded that the HSE with 48% efficiency would outperform the steam turbine on hot water geothermal reservoirs with temperatures up to 275°C. For the 55% efficient HSE, the utilization feasibility could be extended to reservoirs with 300°C temperatures.

2. Economic Comparison

Neither the cost of the geothermal well nor the cost of the fluid discharge system was considered in this analysis. The costs of the generator sets are for complete units; installation costs and the cost of auxiliary geothermal equipment are included as follows:

(1) The cost of the steam turbine unit was $500,000 U.S., the cost of the auxiliary equipment such as separator, silencer, piping, valves and accessories was $104,000 U.S.; cost to install the turbine unit was $25,000 U.S.: cost to install the auxiliary equipment was $40,000 U.S.; then the total cost would be $669,000 U.S.

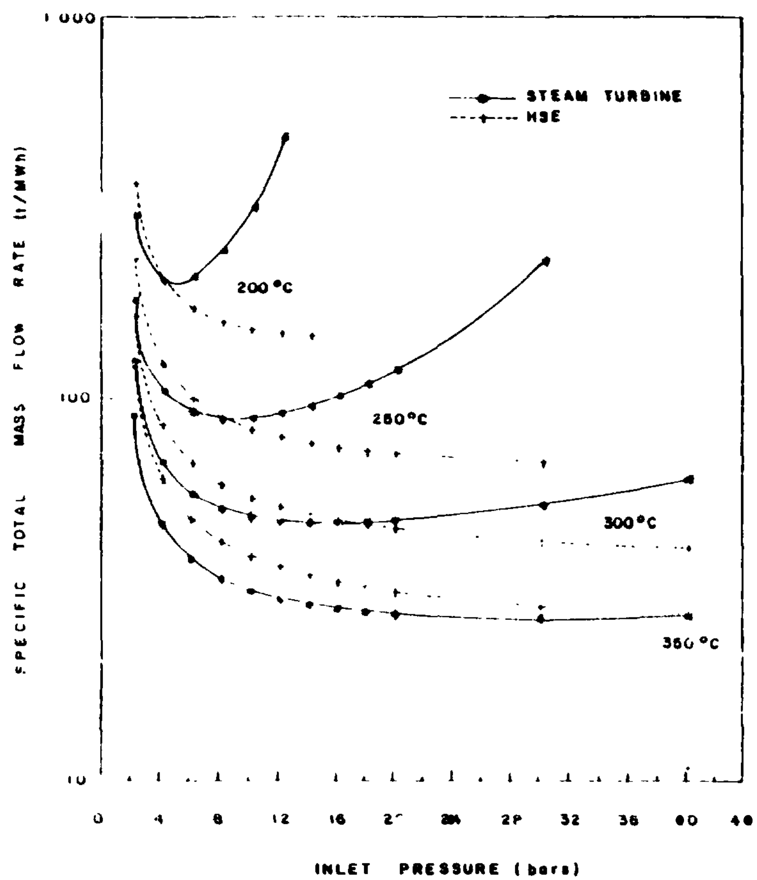
(2) The cost of the HSE unit is $800,000 U.S.; the auxiliary equipment such as piping, silencer valves and instrumentation is estimated at $50,000 U.S.; HSE unit installation is $40,000 U.S.; auxiliary equipment installation is $19,000 U.S.; and total cost is $909,000 U.S.

3. Conclusions

(1) The economic comparison shows that the total installed equipment cost favors use of the 1-MW steam generator.

(2) The HSE with 55% efficiency shows a thermodynamic benefit over the turbine, due to its lower specific total mass flowrate for geothermal wells in hot water systems at temperatures up to 300°C, if it can be operated in the inlet pressure range specified in Table 13-1.

(3) For the HSE with 48% efficiency the thermodynamic benefit over the turbine extends to reservoir temperatures up to 275°C, provided it can be operated in the inlet pressure range specified in Table 13-1. In this application, use of the HSE is feasible.



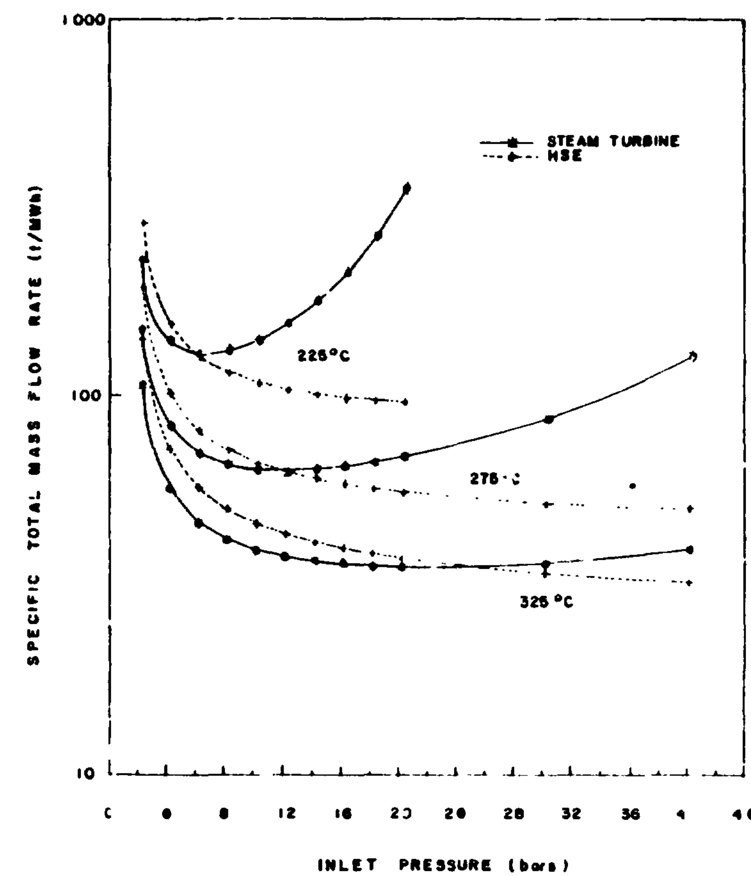


Figure 13-3. Comparison Between HSE (48% Machine Efficiency) and a Steam Turbine for Different Temperatures (Ref. A, Fig. 27)

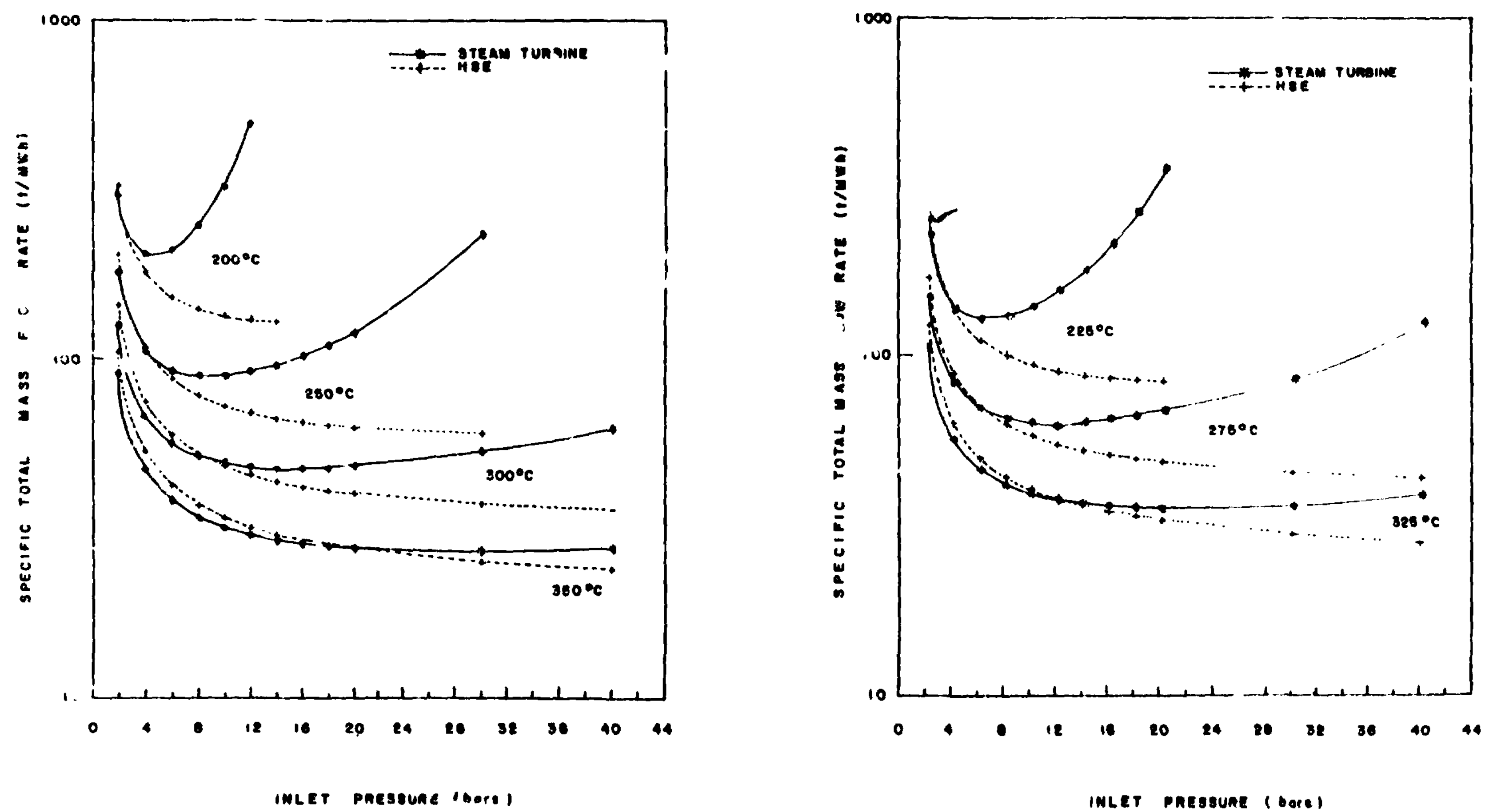


Figure 13-4. Comparison Between HSE (55% Machine Efficiency) and a Steam Turbine for Different Temperatures (Ref. A, Fig. 28)

Table 13-1. Results of Comparison Between HSE and a Steam Turbine for Different Temperatures

Steam Turbine			HSE			
			Rm = 48%		Rm = 55%	
Reservoir Temperature (°C)	Optimum Pressure (bars)	Specific Total Mass Flowrate (Tons/MWh)	Pressure Range (bars)	Specific Total Mass Flowrate (Tons/MWh)	Pressure Range (bars)	Specific Total Mass Flowrate (Tons/MWh)
200	4	204	6 - 14	173 - 147	4 - 14	180 - 128
225	6	129	8 - 20	115 - 97	6 - 20	111 - 84
250	8 - 10	89	10 - 30	83 - 68	8 - 30	78 - 59
275	10 - 14	64	14 - 40	61 - 51	10 - 40	58 - 44
300	14 - 18	47	20 - 40	45 - 40	12 - 40	45 - 35
325	16 - 20	36	30 - 40	34 - 33	16 - 40	35 - 29
350	18 - 20	27	> 40	--------	30 - 40	25 - 23

B. ITALY

1. Technical Considerations

The Cesano 7 well, in the Cesano area, was chosen to carry out the benefit analysis. At the time of the analysis, this well was scheduled to be tested in the future to evaluate the possibility of installing a condensing power plant in the Cesano area. This well is preferable to the Cesano 1 well for this analysis.

The back-pressure production curve of the Cesano 7 well is reported in Figure 13-5. The main thermodynamic characteristics of the well are listed below:

Bottom hole temperature	221°C
Bottom hole static pressure	175 bars
Wellhead enthalpy	972 kJ/kg
CO_2 content	8% of total mass flow rate

The economic comparison was carried out by comparing the turbine and HSE generator units installed in the two different plants shown schematically in Figure 13-6.

a. Technical Features of Plant No. 1. The turbine, item 2, is a universal action type, 1-MW size with an inlet pressure capability ranging between 4 and 20 bars. The turbine can use steam containing from 5% to 40% CO_2 with isentropic efficiency ranging around 75%.

The optimum utilization of geothermal fluid with various total CO_2 content is treated parametrically in Figure 13-7, which shows the specific power produced by a single flash back-pressure unit as a function of wellhead enthalpy. From Figure 13-7 it can be seen that the optimum separator pressure from wellhead enthalpy of 970 KJ/Kg and 8% CO_2 is around 10 bars. The corresponding specific power is 39 kJ/kg. The necessary mass flowrate, G, of Cesano 7 fluid will be:

$$G = \frac{1000 \text{ kW}}{39 \text{ kJ/kg}} \times 3.6 \text{ conversion factor} = 93 \text{ tons/h}$$

From the characteristic curve the wellhead pressure will be around 25 bars for this flowrate. The calculated energy and mass balances for 1000 kW are shown in Figure 13-6.

The maximum power from Cesano 7 with this type of plant requires a wellhead pressure of 10 bars to yield 165 tons/h, and

$$\frac{165}{93} \times 1000 \text{ kW} = 1770 \text{ kW}$$

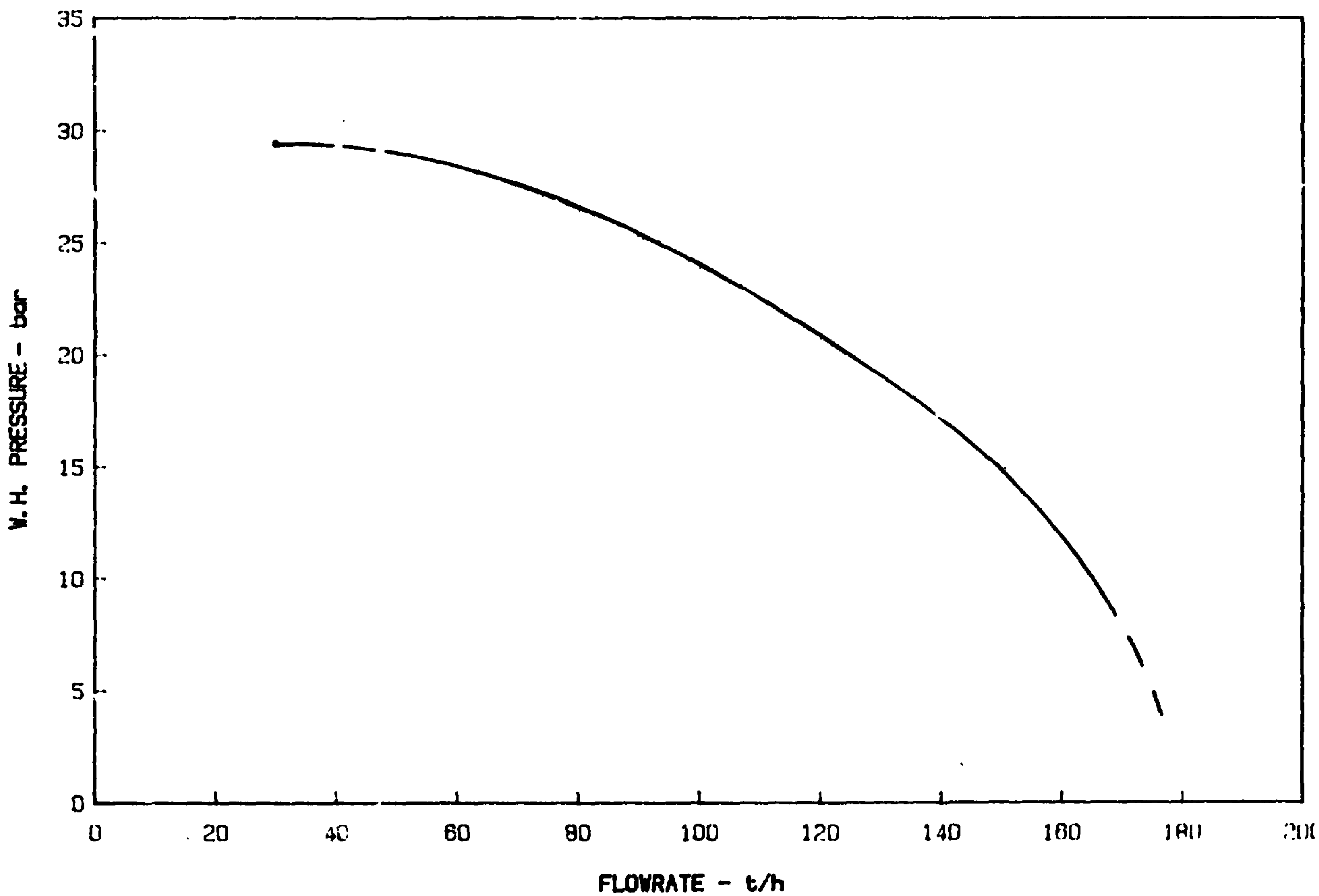


Figure 13-5. Cesano 7 Back-Pressure Curve (Ref. B, Fig. 15)

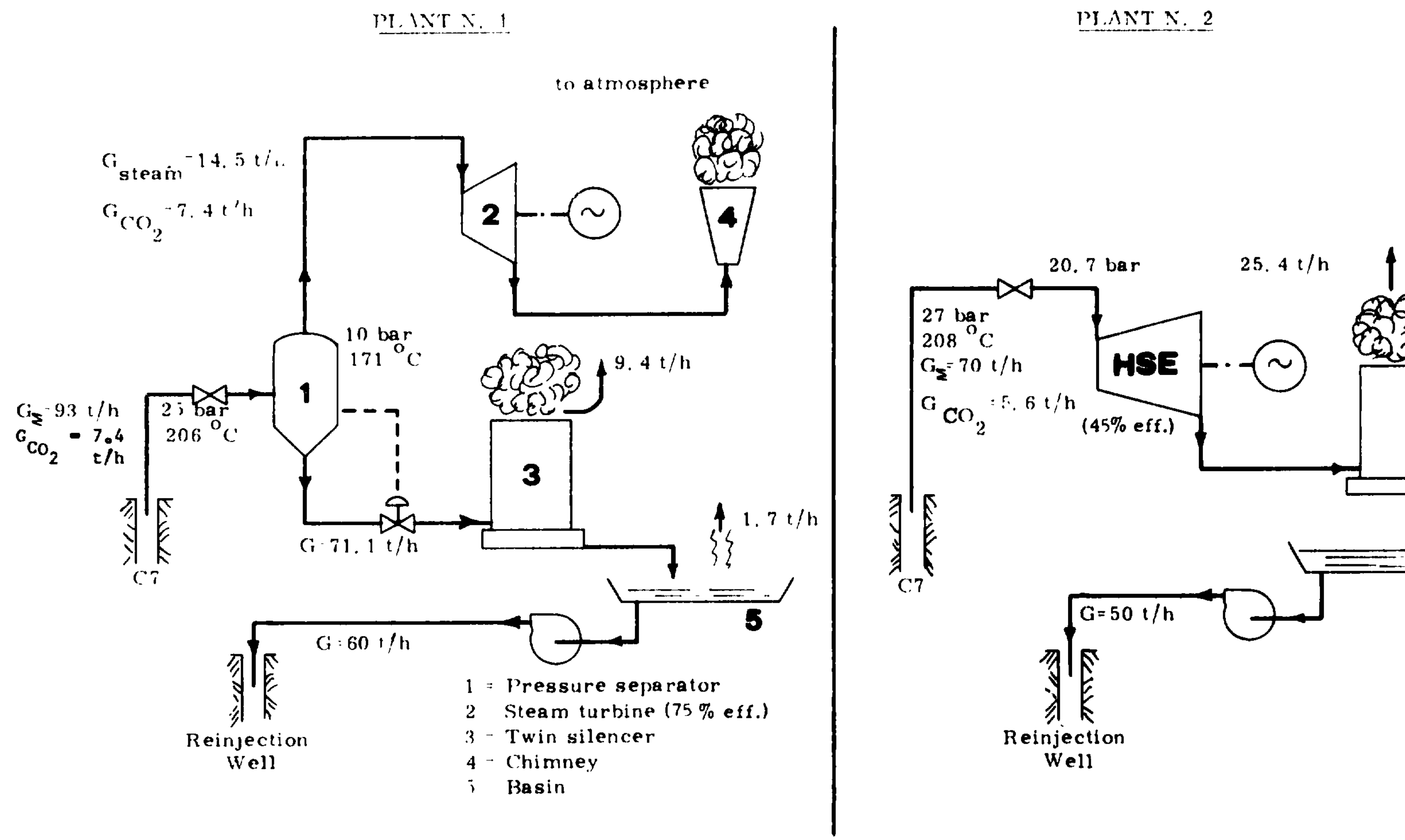


Figure 13-6. Schematic Diagrams of Two Back-Pressure Plants to Utilize Cesano 7 Brine (Ref. 8, Fig. 16)

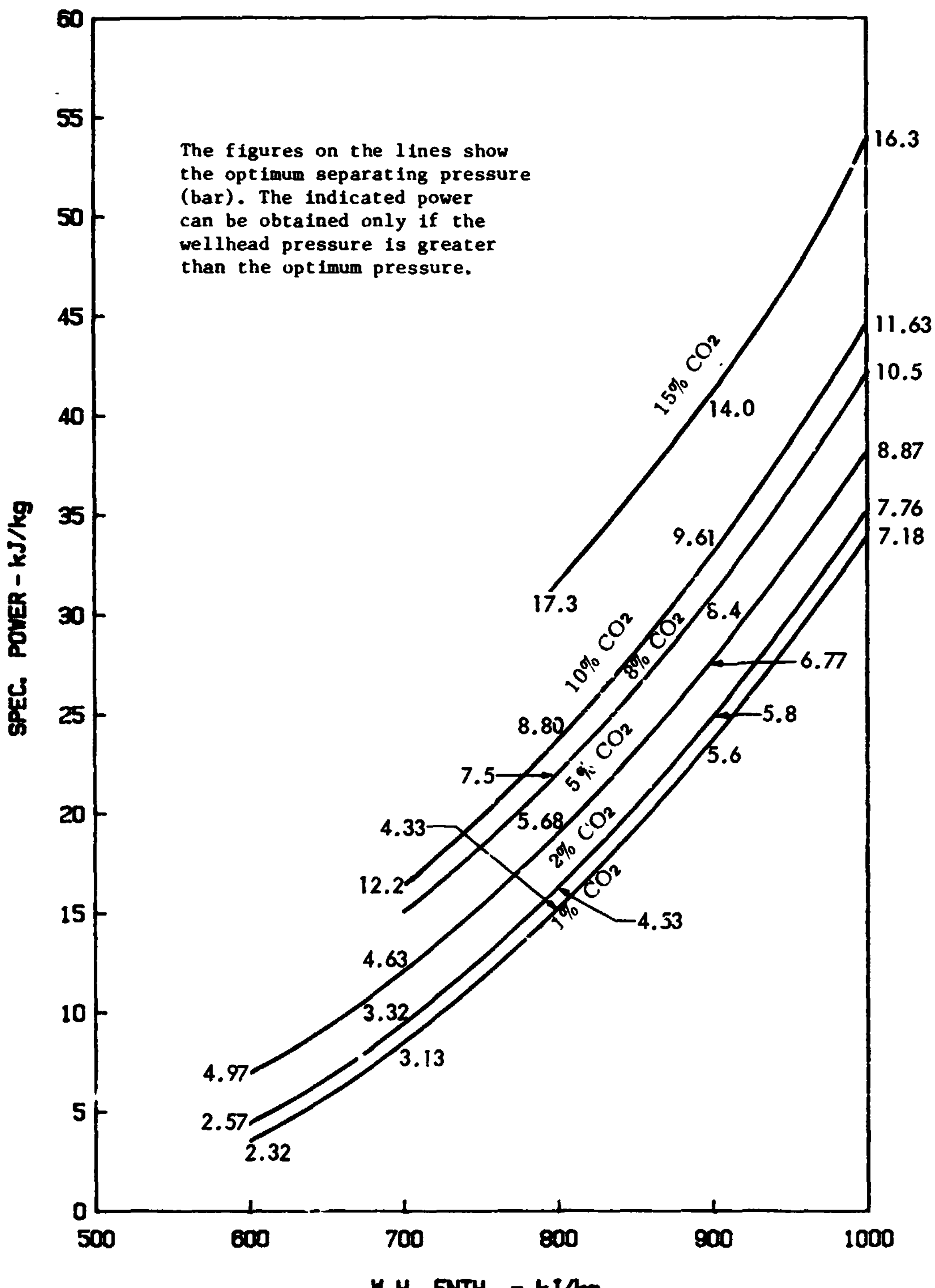


Figure 13-7. Specific Power vs. Wellhead Enthalpy for a Single Flash Back-Pressure Unit (Ref. 8, Fig. 17)

b. Technical Features of Plant No. 2. In Figure 13-8 the enthalpy drop across the HSE for various Cesano 7 wellhead pressures is shown for different HSE efficiencies. By coupling this result with the back-pressure curve of Cesano 7 it is possible to find the maximum recoverable power. If the HSE efficiency were 45%, the maximum power would be around 1960 kW. Since the maximum upstream allowable pressure of the HSE is 20.7 bars, the energy and mass balances are as shown in Figure 13-6.

2. Economic Considerations

The cost of the reinjection line, water collecting pit, twin silencers, pipelines, safety valves and civil works can be considered the same in the two cases.

a. Plant No. 1. The separator should be designed in such a way so as to separate steam from 4 to 20 bars. The separators could be designed with the following specifications:

Maximum pressure	21 bars
Liquid flowrate	100 tons/h
Saturate steam flowrate	30 tons/h
Operating pressure	10 bars
Material	carbon steel

The estimated cost of this separator fitted with safety valves, regulating valves and piping is around 160 ML (million lira) ($107,000 U.S.). The estimated cost for mounting the separator can be estimated as 60 ML ($40,000 U.S.).

The installed cost of the turbine, generator and ancillary equipment is around 800 ML ($535,000 U.S.) without considering the design cost.

The total cost will be 1020 ML ($682,000 U.S.).

b. Plant No. 2. The declared cost of the HSE unit in October 1980 was $636,800 U.S. (included ancillary equipment).

The estimated cost of installation, safety valves, etc., is around 60 ML ($40,000 U.S.).

By applying a cost escalation factor (Chemical Engineering, February 7, 1983) it is possible to obtain the cost in 1983 $ U.S.:

$$636{,}800 \times \frac{315}{261} = \$768{,}551 \text{ U.S., say } \$770{,}000\text{, or about 1150 ML.}$$

Total cost: 1210 ML ($810,000 U.S.).

3. Conclusions

From the above considerations it was concluded that:

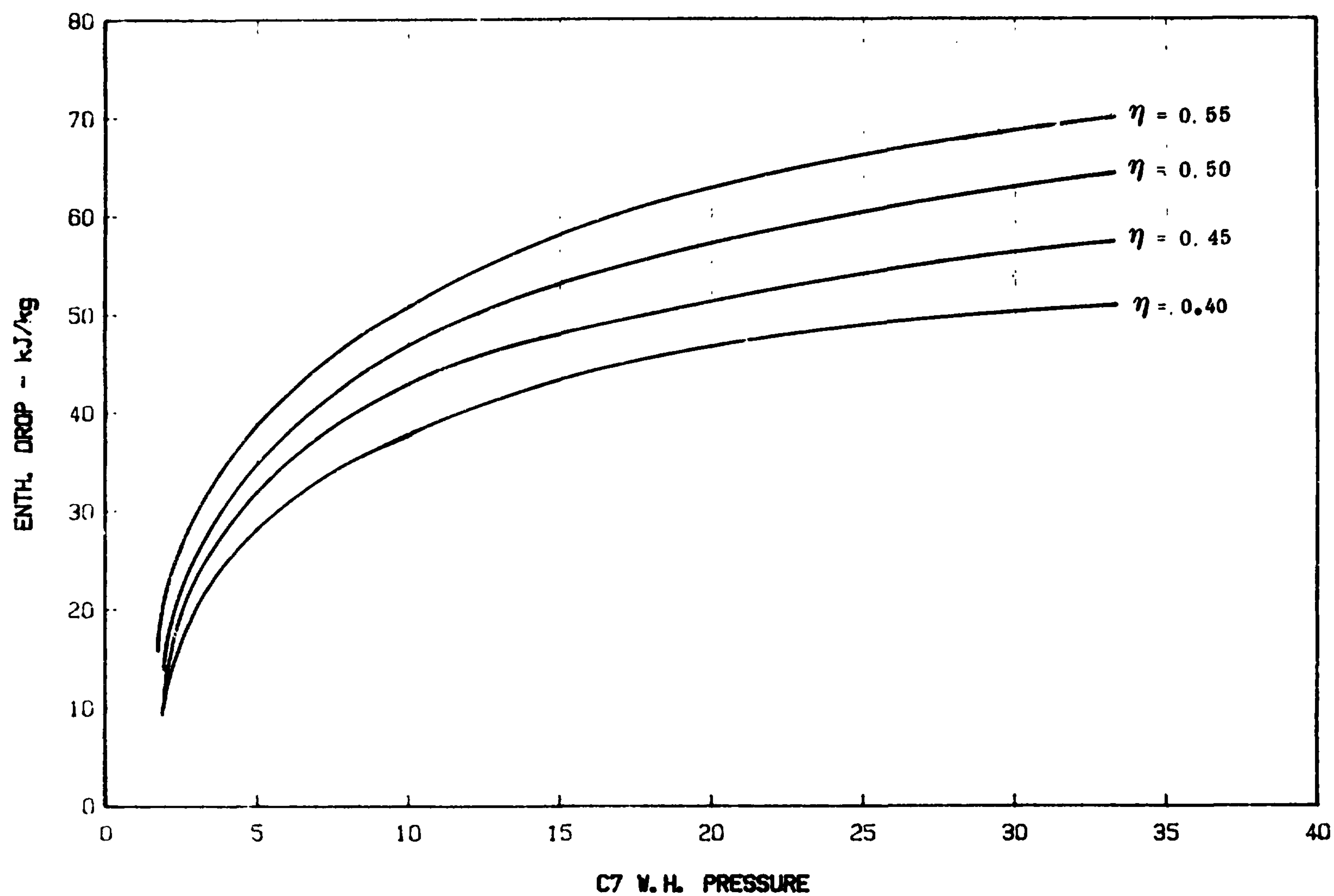


Figure 13-8. Specific Enthalpy Drop for Various HSE Efficiencies as a Function of Cesano 7 Wellhead Pressure (Ref. B, Fig. 18)

(1) The cost of the two plants can be considered almost the same: these plants should be designed to be utilized on different wells. The higher installation cost of plant No. 1 with the turbine will balance the higher costs of Plant No. 2 using the HSE with its multiple use.

(2) Plant No. 2 shows a higher overall efficiency than Plant No. 1, assuming an HSE efficiency of 45%. The maximum recoverable power from Cesano 7 is 1770 kW with Plant No. 1 against about 2000 kW with Plant No. 2. It is thus possible to save "geothermal fuel" by utilizing Plant No. 2.

(3) The reinjection costs are lower for Plant No. 2.

C. NEW ZEALAND

The power generating potential and capital cost of the HSE were compared with those of a small steam turbine, with both units being back-pressure sets capable of generating 1 MW of electrical energy.

1. Power Potential Comparison of the Helical Screw Expander vs. the Steam Turbine

A brief, theoretical study evaluating the power generating potential of the HSE and a steam turbine, using a specified geothermal resource was undertaken. Five fluid enthalpies characteristic of liquid-dominated geothermal resources were used in the study.

Assumptions:

(1) Isentropic efficiency:

(a) 1-MW HSE, 45% (observed during the endurance tests).

(b) 1-MW steam turbine, 60%.

(2) Exhaust pressure 14.5 psia.

(3) Maximum stable operating pressure for the HSE was taken to be 195 psia.

(4) Pipeline friction and energy losses were neglected.

(5) The power output curves were based on a unit mass flowrate of geothermal well fluid.

For each fluid enthalpy, power output curves were prepared as a function of inlet pressure, as shown in Figure 13-9.

The steam turbine optimum power output occurs as the maximum product of the steam mass flowrate determined by isenthalpic flash conditions and the corresponding isentropic drop from the flash pressure.

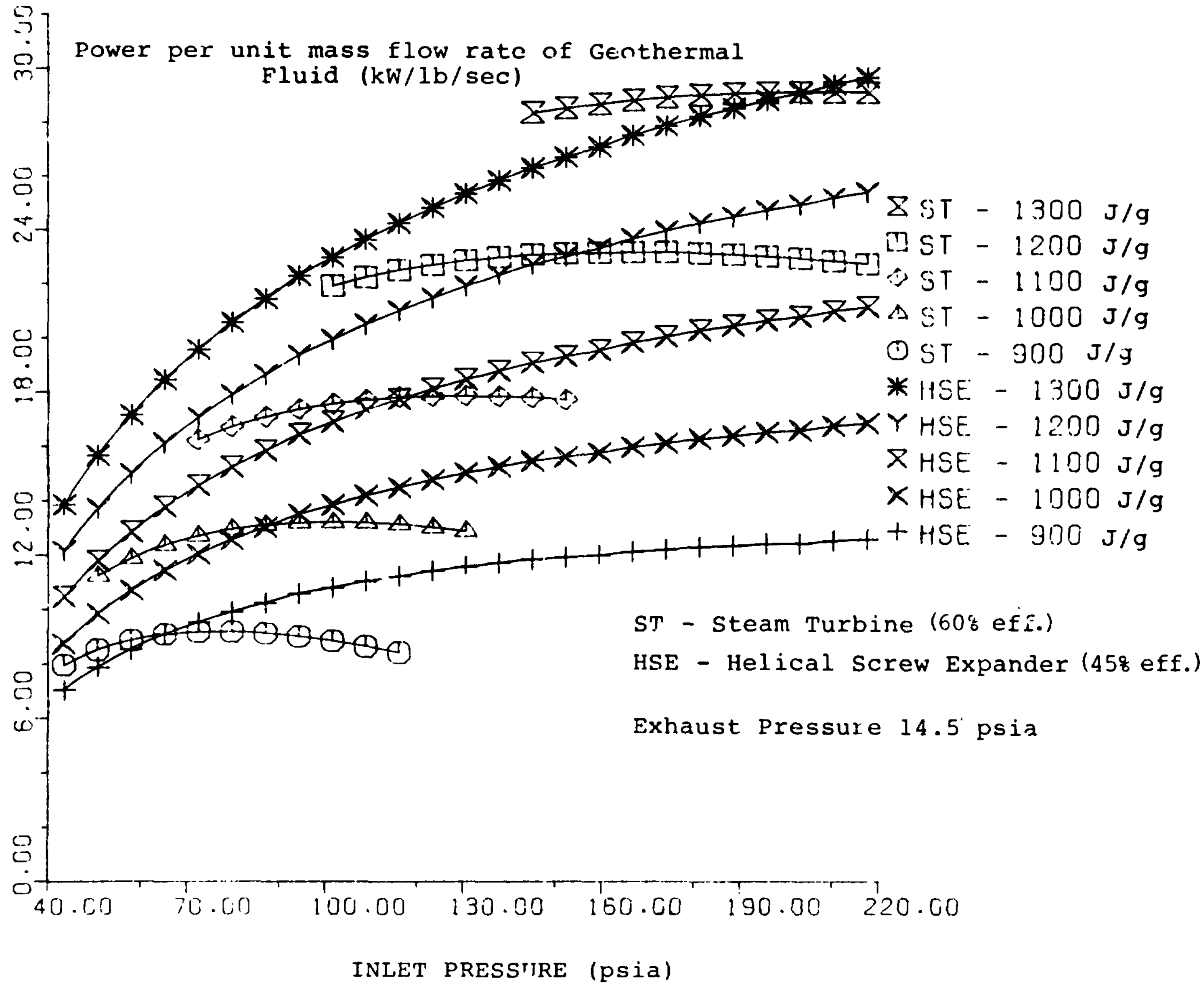


Figure 13-9. Power Potential Curves for the Helical Screw Expander and a Steam Turbine (Ref. C, Fig. 6.1)

The theoretical maximum power output from a given resource using the HSE occurs at the maximum stable operating pressure. This corresponds to the greatest available isentropic enthalpy drop at which stable operation can be maintained.

The optimum conditions have been extracted from the generated curves, Figure 13-9, and are tabulated in Table 13-2.

Table 13-2. Optimum Power

Fluid Enthalpy		HELICAL SCREW EXPANDER		STEAM TURBINE	
		Inlet Pressure	Power	Inlet Pressure	Power
J/g	Btu/lb	psia	kW/lb/s	psia	kW/lb/s
900	387	195	12.4	79	9.2
1000	430	195	16.5	101	13.2
1100	473	195	20.6	130	17.8
1200	516	195	24.7	166	23.6
1300	559	195	28.8	203	29.1

For the optimum conditions it can be seen that the HSE requires a smaller mass flowrate of geothermal fluid than is required by a steam turbine to produce 1 MW of electrical power output when operating on a geothermal resource with an enthalpy of 1200 J/g (516 Btu/lb) or less.

It has been assumed that the mass flowrate of geothermal fluid required for 1 MW of electrical power output can be sustained at the optimized inlet pressures. This assumption is valid for the Broadlands well BR 19, where the wellhead discharge pressures to sustain the required mass output occur above 435 psia (30 bar abs). For geothermal wells where this is not valid, the mass flowrate with wellhead pressure has to be considered.

2. Cost Information

Budget cost information was obtained for both the HSE and steam turbine units. The equipment included the alternator, electrical control equipment and ancillary plant for the proper functioning of the generating sets.

The cost information was as of March 15, 1983:

(1) HSE Unit, $800,000 U.S. - Budget cost supplied verbally by the Hydrothermal Power Company (revised October 3, 1983).

(2) Steam Turbine Unit, $220,000 U.S. - Budget cost for a multi-stage 1-MW standard frame turbine suitable for geothermal service.

The separator, water vessel and additional pipework required for the steam turbine was estimated at $50,000 U.S. by the Ministry of Works and Development.

3. Discussion and Conclusion

The potential of the HSE on lower-enthalpy geothermal resources for greater power production than can be achieved by a small steam-turbine generator is shown in Table 13-2. From the Broadlands well BR 19 with an average fluid enthalpy of 1250 to 1300 J/g, the power generating potential for both the HSE and the steam turbine are similar. Capital investment clearly favors the steam turbine generating set. This comparison does not consider operating costs because the endurance test disclosed deficiencies that must be remedied before meaningful operating and maintenance costs can be identified. For the Broadlands BR 19 site there is clearly no financial benefit to be gained from installing an HSE, based on capital costs.

D. COST/BENEFIT ANALYSIS SUMMARY AND DISCUSSION

The costs presented in the analyses are summarized in Table 13-3, which shows the cost of the equipment, the installation costs, and the cost totals. Costs of operation, maintenance, overhaul, and depreciation of the equipment were omitted from the analysis for lack of data.

In the analyses, the benefit of using the Model 76-1 HSE power plant in comparison with the turbine generator set was based on the thermodynamic performance of the machines on easily manageable fluids. The HSE was shown to cost more but have a performance advantage over the turbine for each of the test locations, although the advantage was not large for HSE efficiencies taken as 45% to 48% The performance advantage was considered sufficient by CFE and ENEL for usage of the HSE to be feasible for certain wells. For higher efficiencies or lower-enthalpy reservoirs, the advantage of using the HSE increases.

During the testing of the HSE, it was demonstrated that the machine was tolerant of process upsets leading to flooding of the inlet or of the exhaust up to the rotors. The benefits of characteristics such as this, or tolerance to scaling brine, if any, were outside the scope of the analyses. The possible decay in field productivity and the need to operate the prime mover off-design and the effect on prime mover efficiency were also outside the scope of the analyses.

Table 13-3

Cost Summary (U.S. $), Cost/Benefit Analysis

Country	Turbine	Installation	Installed	Separator & Piping, etc.	Installation	Installed	Total
Mexico	500,000	25,000	525,000	104,000	40,000	144,000	669,000
Italy			535,000	107,000	40,000	147,000	682,000
New Zealand(1)	220,000	135,000	355,000	50,000	30,000	80,000	435,000

Country	HSE	Installation	Installed	Separator & Piping, etc.	Installation	Installed	Total
Mexico	800,000	40,000	840,000	50,000	19,000	69,000	909,000
Italy	770,000	40,000	810,000	0	0	0	810,000
New Zealand(1)	800,000	135,000 (2)	935,000	0	0	0	935,000

(1) Costing is comparative and not absolute. Costs that would be incurred for both installations are not considered.

(2) Cost based on the cost to transport and install the HSE in New Zealand using all new equipment. Cost does not include transmission lines, disposal of waste liquid, grid synchronization equipment, etc.

SECTION XIV

APPLICATIONS

A. MEXICO

From a practical point of view, the use of the HSE in Mexico is entirely feasible as indicated by the thermodynamic performance and distribution of failures that occurred during the tests. The application of an HSE power plant using geothermal fluids at the wellhead can be attractive because it can use the fluids in the natural condition of unseparated steam and brine in geothermal fields under development, or on exploratory wells to:

(1) Verify the operability of highly scaling fluids at different operating pressures.

(2) Evaluate procedures to reduce or eliminate scaling in [illegible] equipment.

(3) Perform production tests to check the geothermal reserves of the fields.

(4) Investigate the relation between the productive process of the field and its recharging through reinjection.

B. ITALY

The main use of the HSE power plant in Italy would be as a wellhead back-pressure unit. The machine can be used conveniently in this manner during the initial phase of exploitation of water-dominated reservoirs when it is necessary to collect production information before the installation of larger power plants. (In Italy there are new fields at Latera, Mofete and Cesano where the HSE could be used for this purpose.)

C. NEW ZEALAND

Application of Model 76-1 HSE power plant for general geothermal service in New Zealand will require lower pricing and demonstration of improved reliability.

SECTION XV

REFERENCES

A. Status Report of the Test and Demonstration Programme for 1 MW Wellhead Generator on Cerro Prieto; Comision Federal de Electricidad, Coordinadora Ejecutiva de Cerro Prieto, Mexico, October 1981, revised January 1984.

B. Helical Screw Expander International Test and Demonstration Programme Status Report of Tests in Cesano (Italy), Ente Nazionale per l'Energia Elettrica-Unità Nazionale Geotermica, Pisa, Italy, October 1982, revised June 1983.

C. IEA Programme on Research, Development and Demonstration on Geothermal Equipment, Test and Demonstration of a 1 MW Wellhead Generator, Ministry of Works and Development, New Zealand, prepared by B. S. Carey, June 1983.

1.* Helical Screw Expander Evaluation Project Final Report, Richard McKay, March 1, 1982, JPL Publication No. 82-5; DOE/ET-28329-1, Distribution Category UC-66D. This report may be ordered under the DOE Accession No., DOE/ET-28329-1, or the NASA Accession No., N82-22659, from the National Technical Information Service (NTIS), U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161.

2.* Design, Fabrication, Delivery, Operation and Maintenance of a Geothermal Power Conversion System, Hydrothermal Power Co., Ltd., December 1980, NASA-CR-168653. This report may be ordered under the NASA Accession No., N82-20644, from NTIS (see Ref. 1 above).

* Numbered references are compatible with usage in Refs. B and C.

C-2

APPENDIX A

MEXICO/CFE

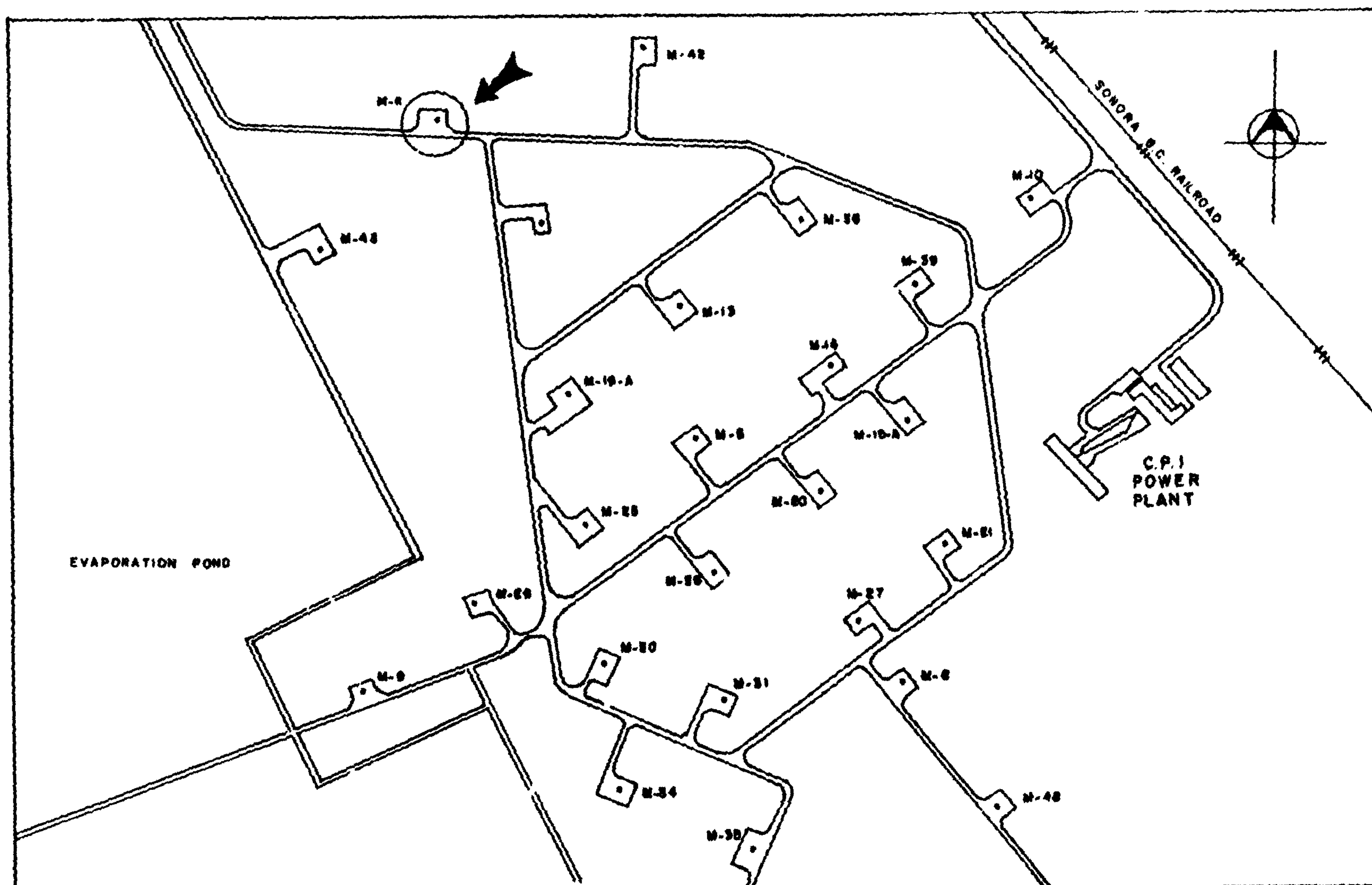


Figure A-1. Well Location, Cerro Prieto Geothermal Field (Ref. A, Fig. 1)

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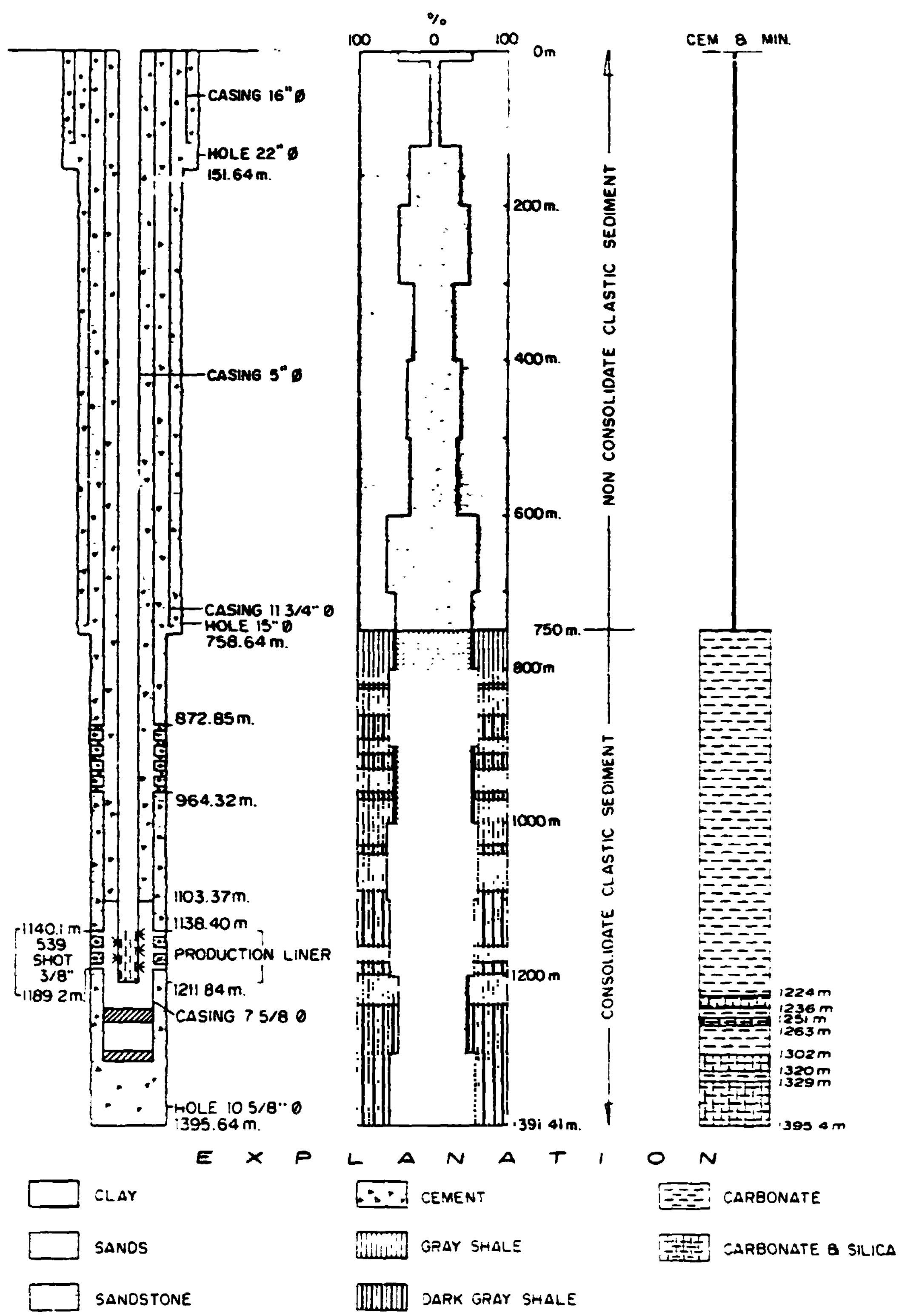

Figure A-2. Well Completion and Geological Information of Well M-11 (Ref. A, Fig. G.1)

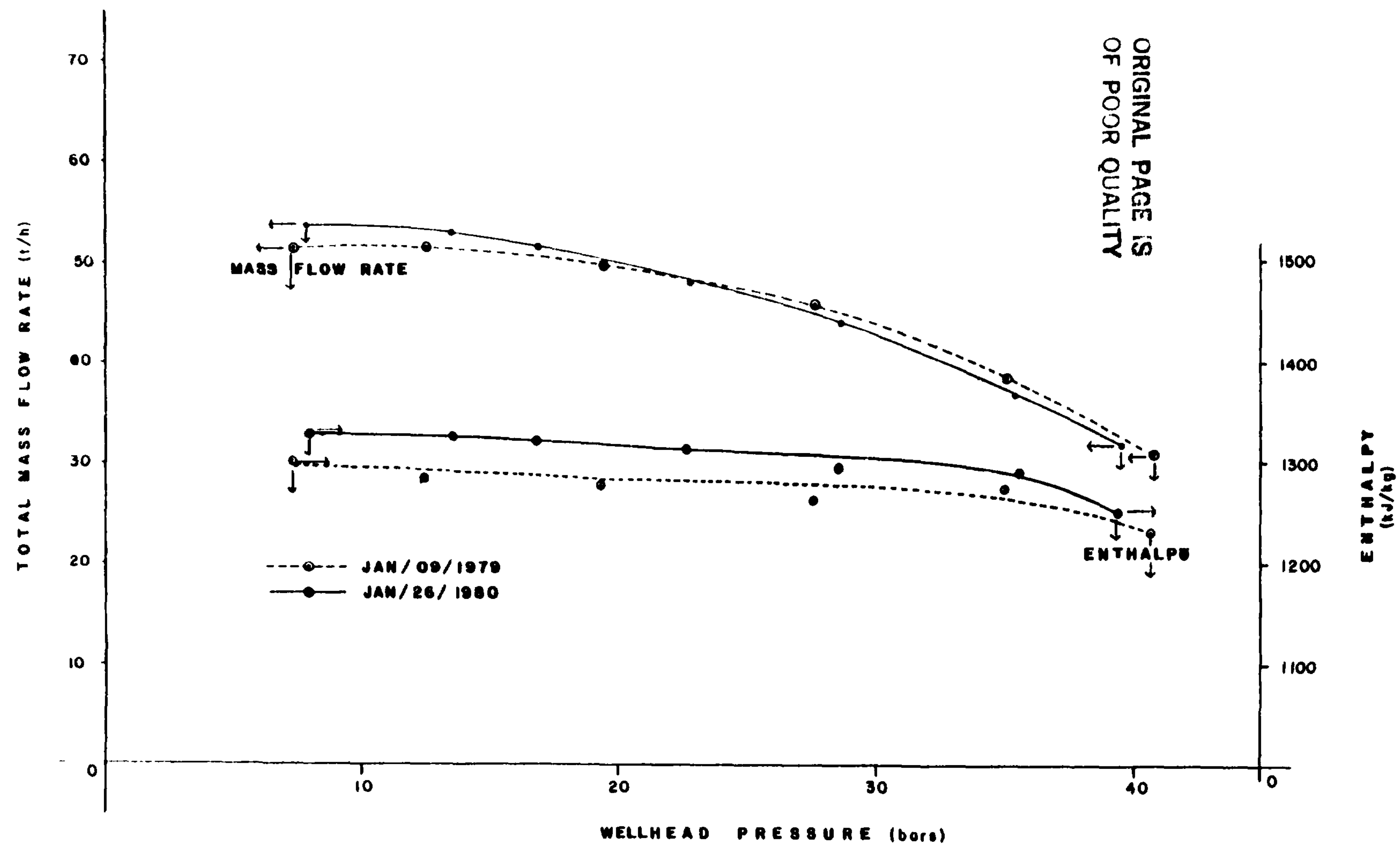

Figure A-3. Production Characteristic Curves for Well M-11, Comparison Between 1979 and 1980 (Ref. A, Fig. 23)

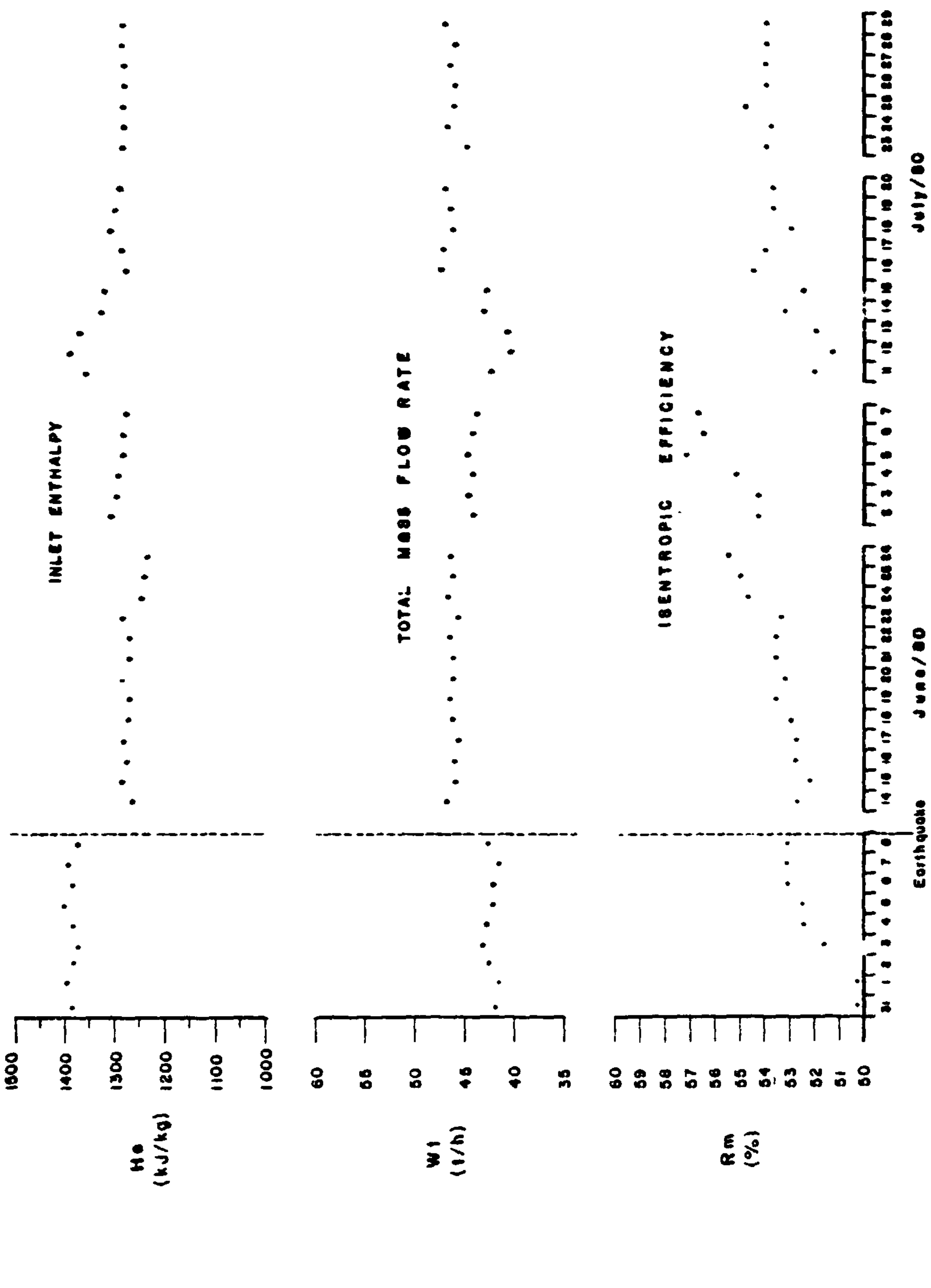

Figure A-4. Endurance Test, Daily Average Values (Ref. A, Fig. 10)

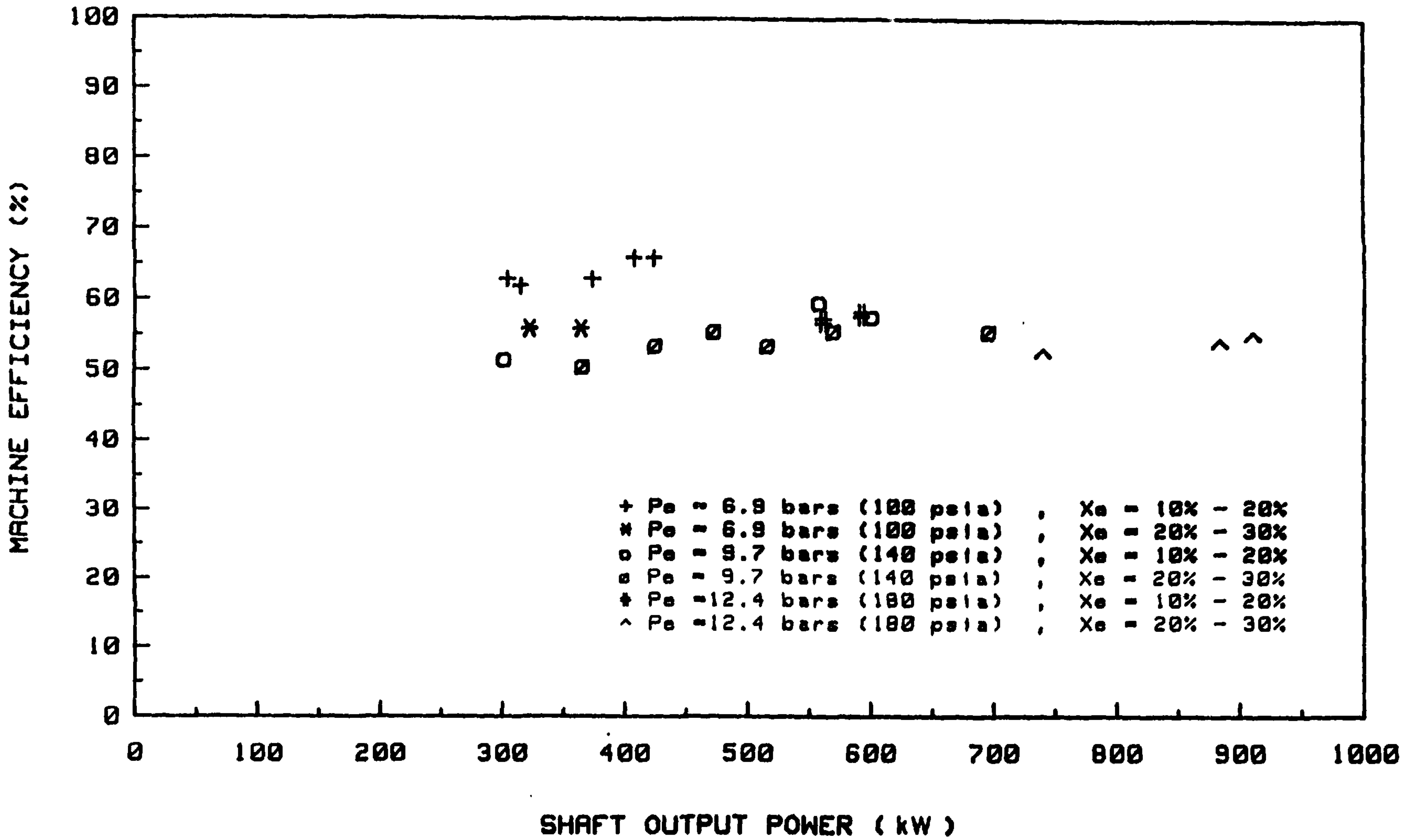

Figure A-5. Downstream Test at 3000 rpm, All Inlet Conditions (Ref. A, Fig. 11)

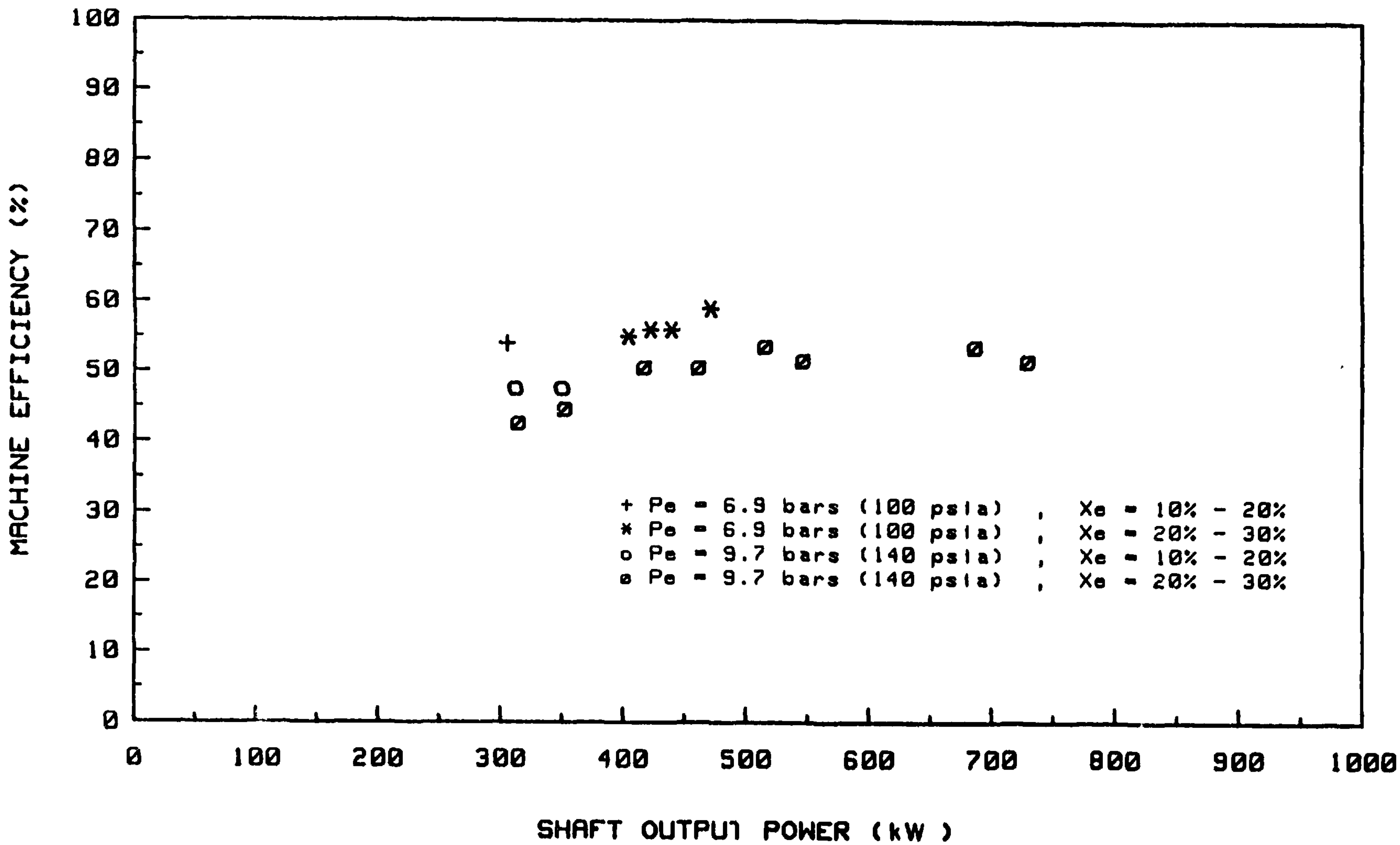

Figure A-6. Downstream Test at 4000 rpm, All Inlet Conditions (Ref. A, Fig. 12)

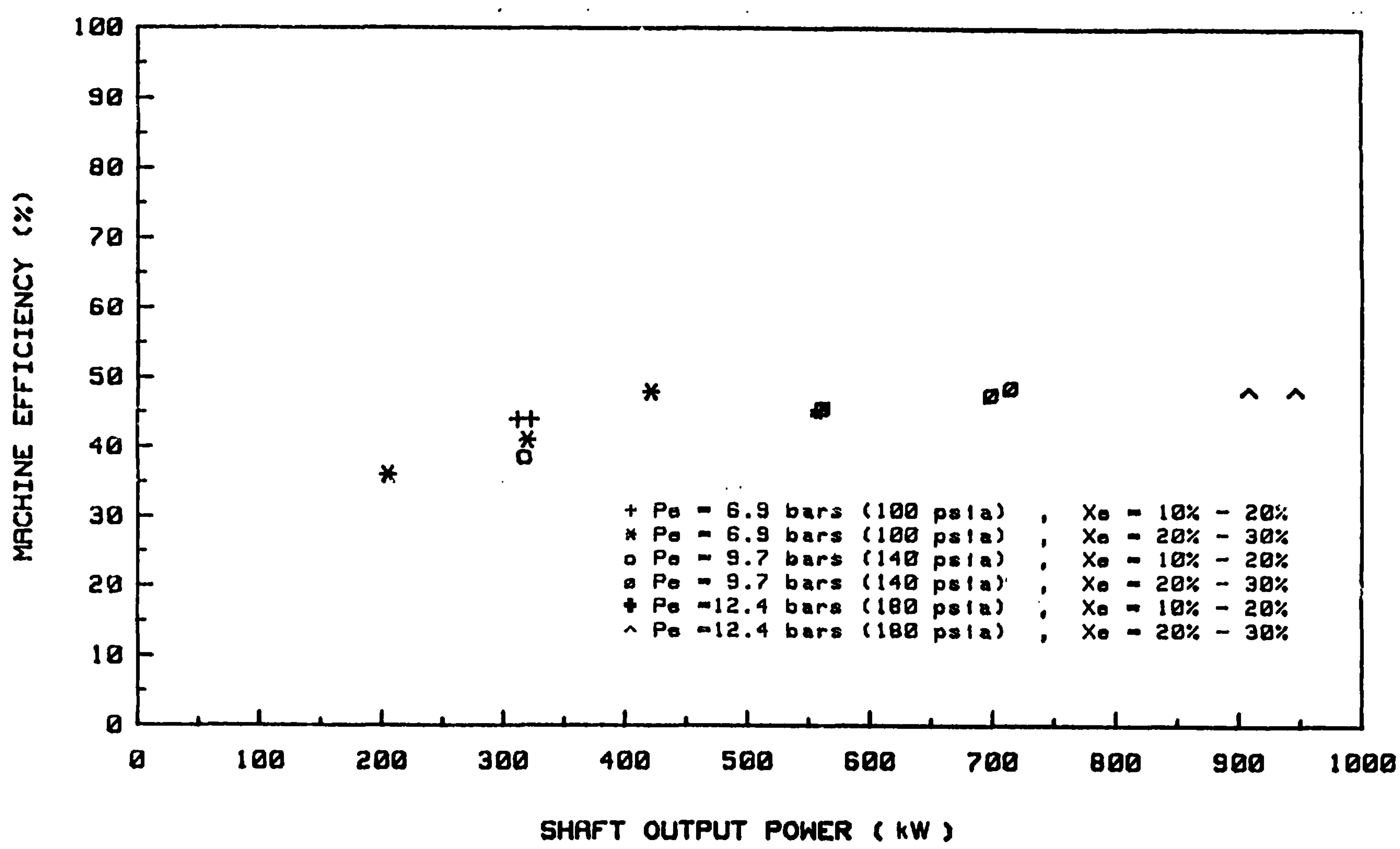

Figure A-7. Upstre‹ n Test at 3000 rpm, All Inlet Conditions (Ref. A, Fig. 13)

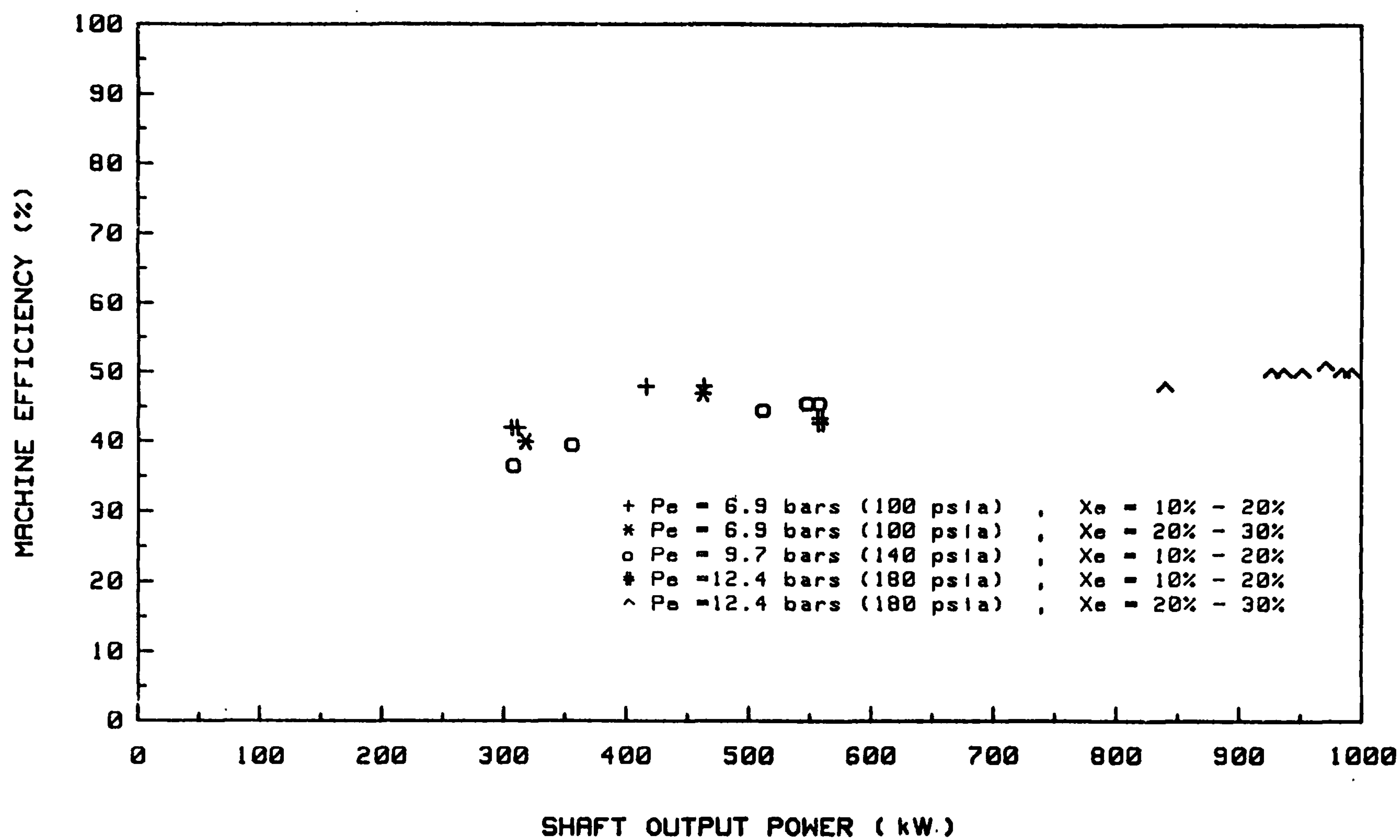

Figure A-8. Upstream Test at 4000 rpm, All Inlet Conditions (Ref. A, Fig. 14)

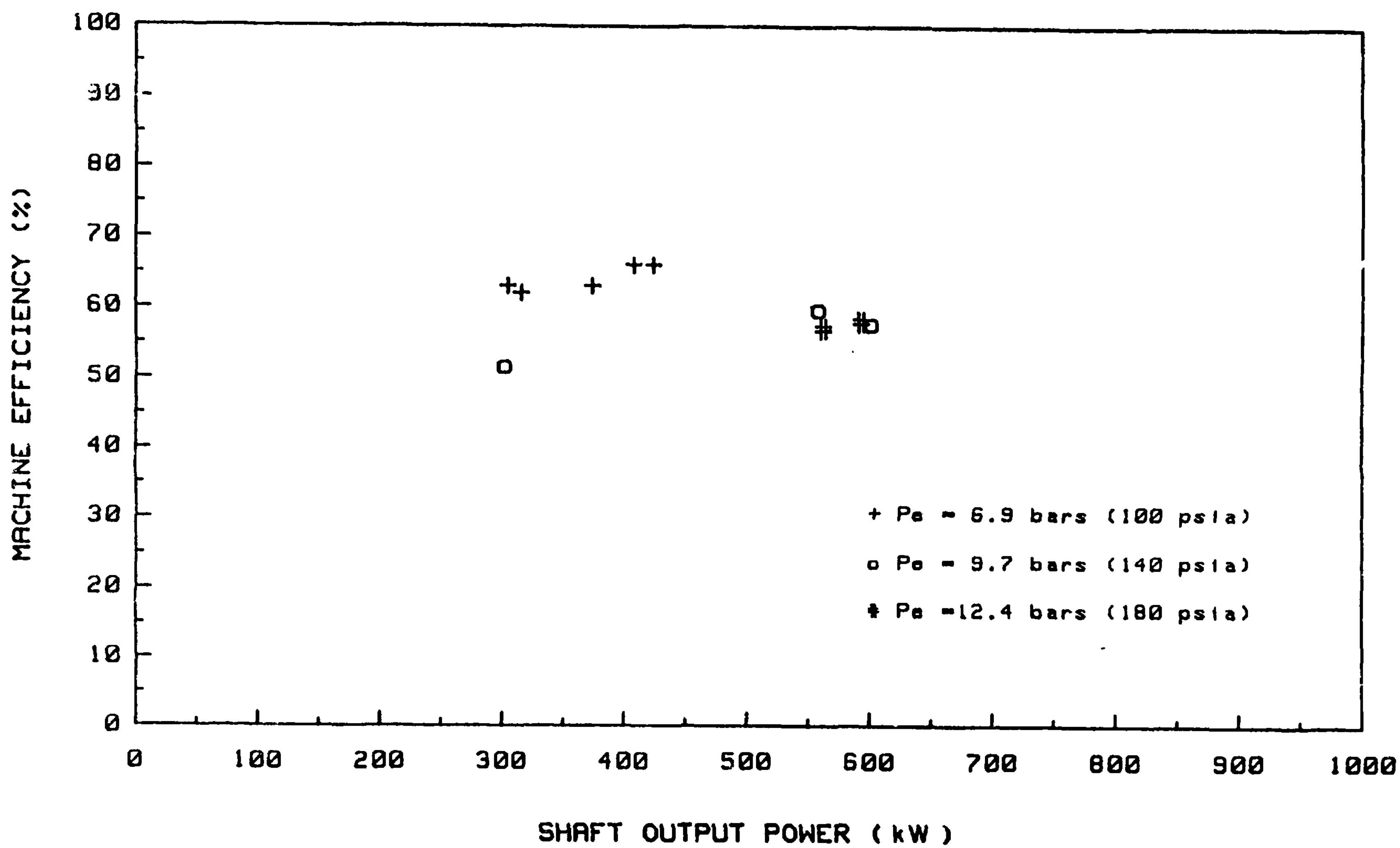

Figure A-9. Effect of Inlet Pressure on Machine Efficiency for Downstream Test at 3000 rpm, Inlet Quality 10% to 20% (Ref. A, Fig. 15)

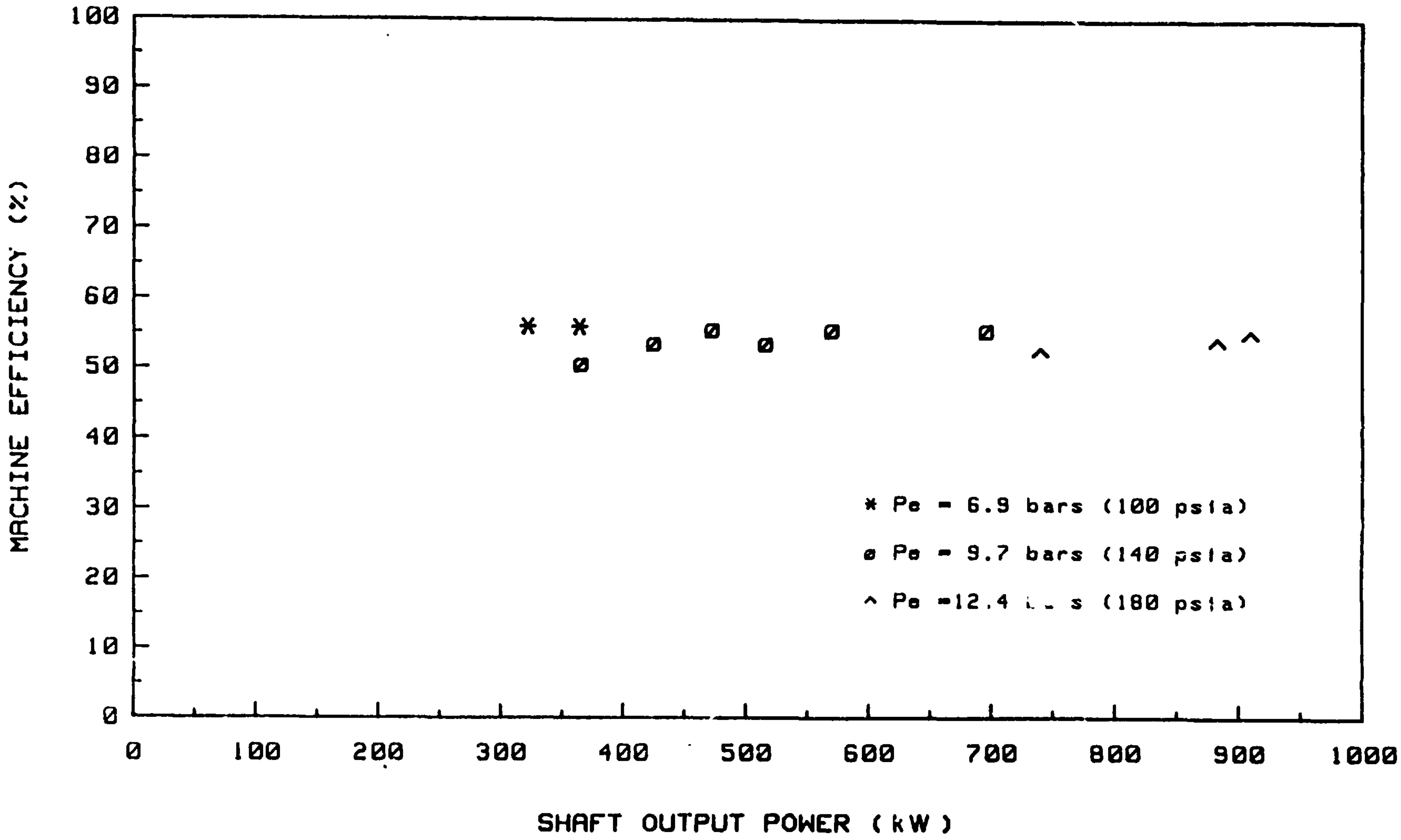

Figure A-10. Effect of Inlet Pressure on Machine Efficiency for Downstream Test at 3..00 rpm, Inlet Quality 20% to 30% (Ref. A, Fig. 16)

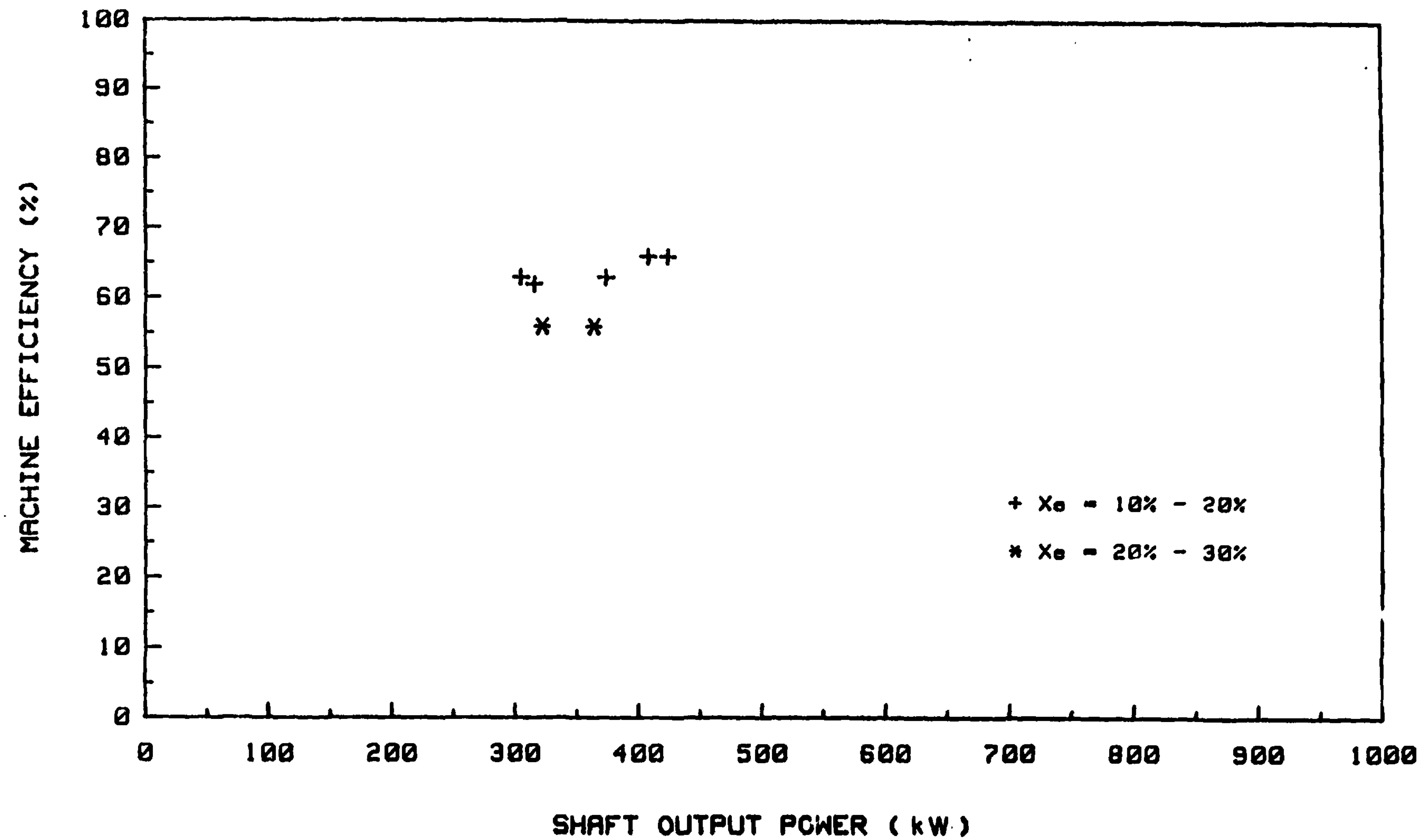

Figure A-11. Effect of Inlet Quality on Machine Efficiency for Downstream Test at 3000 rpm, Inlet Nominal Pressure 100 psia (Ref. A, Fig. 17)

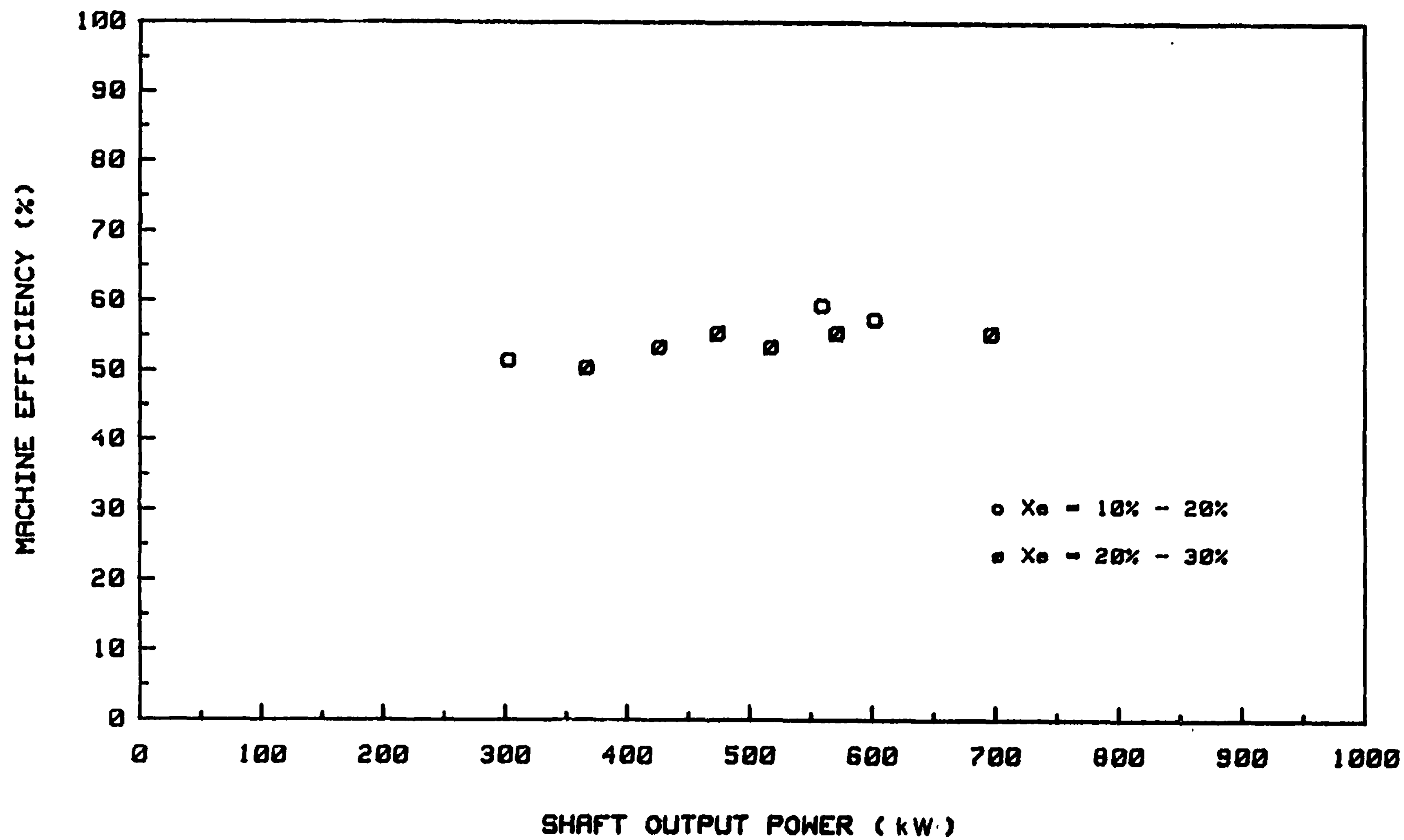

Figure A-12. Effect of Inlet Quality on Machine Efficiency for Downstream Test at 3000 rpm, Inlet Nominal Pressure 140 psia (Ref. A, Fig. 18)

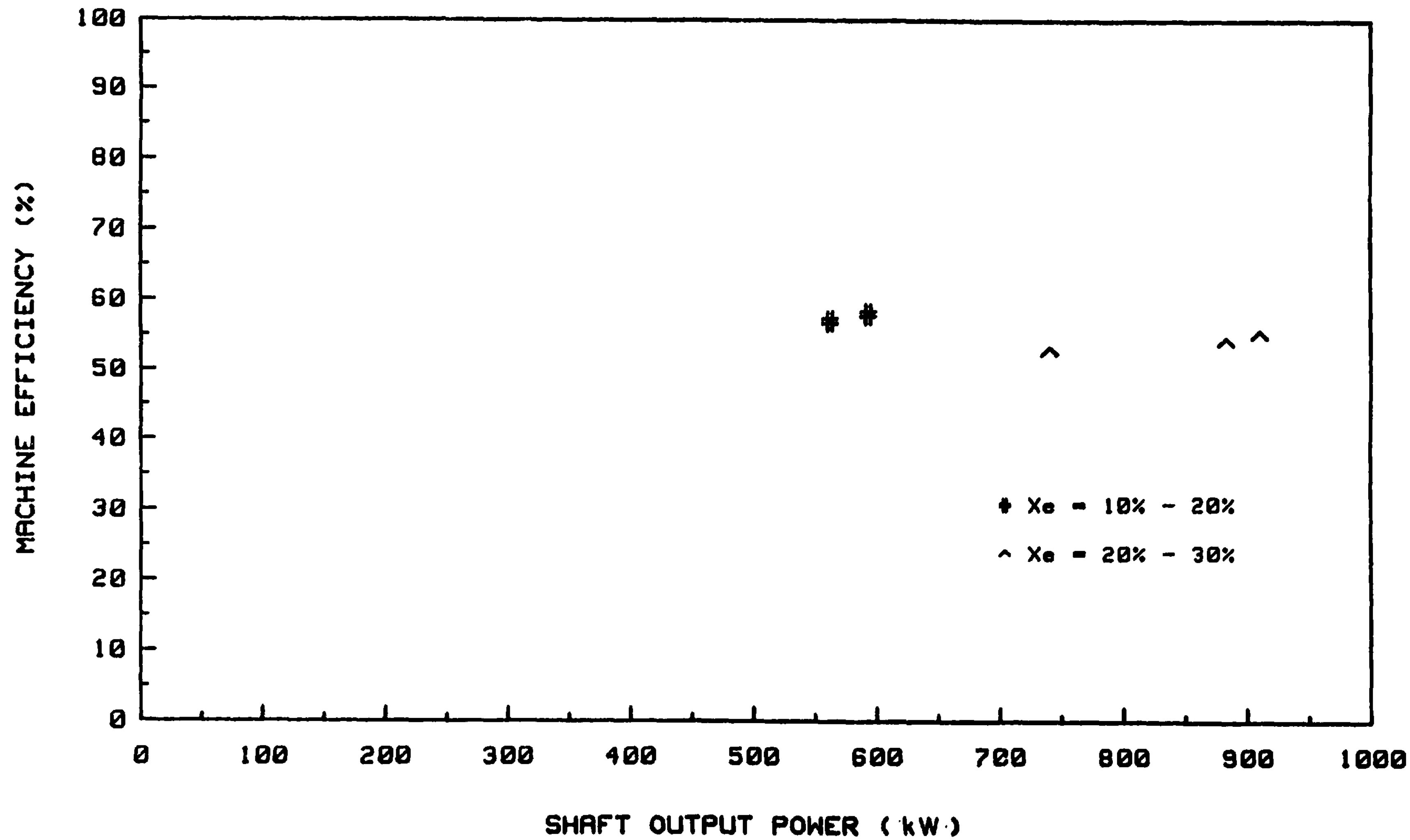

Figure A-13. Effect of Inlet Quality on Machine Efficiency for Downstream Test at 3000 rpm, Inlet Nominal Pressure 180 psia (Ref. A, Fig. 19)

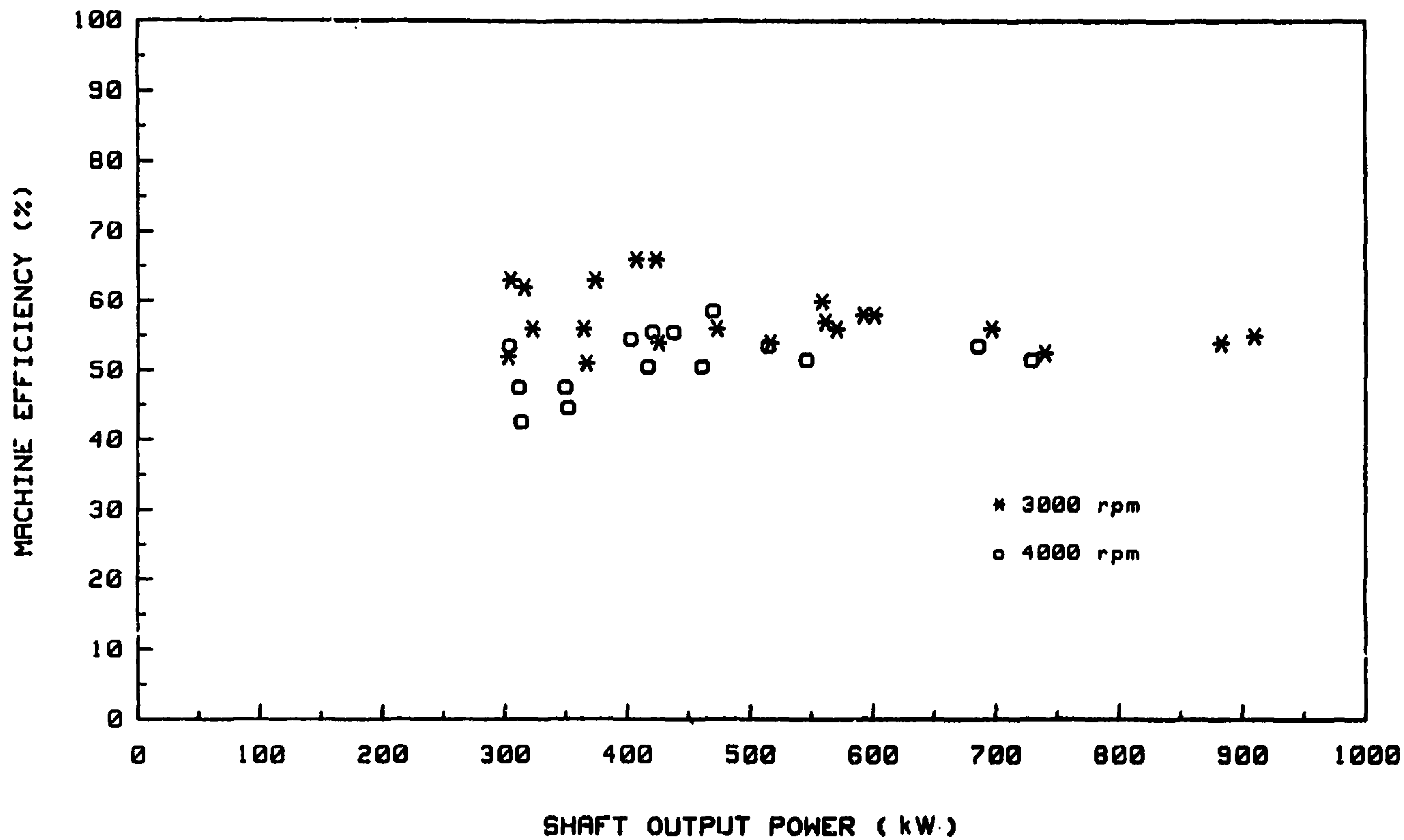

Figure A-14. Effect of Rotor Speed on Machine Efficiency for Downstream Test, All Inlet Conditions (Ref. A, Fig. 20)

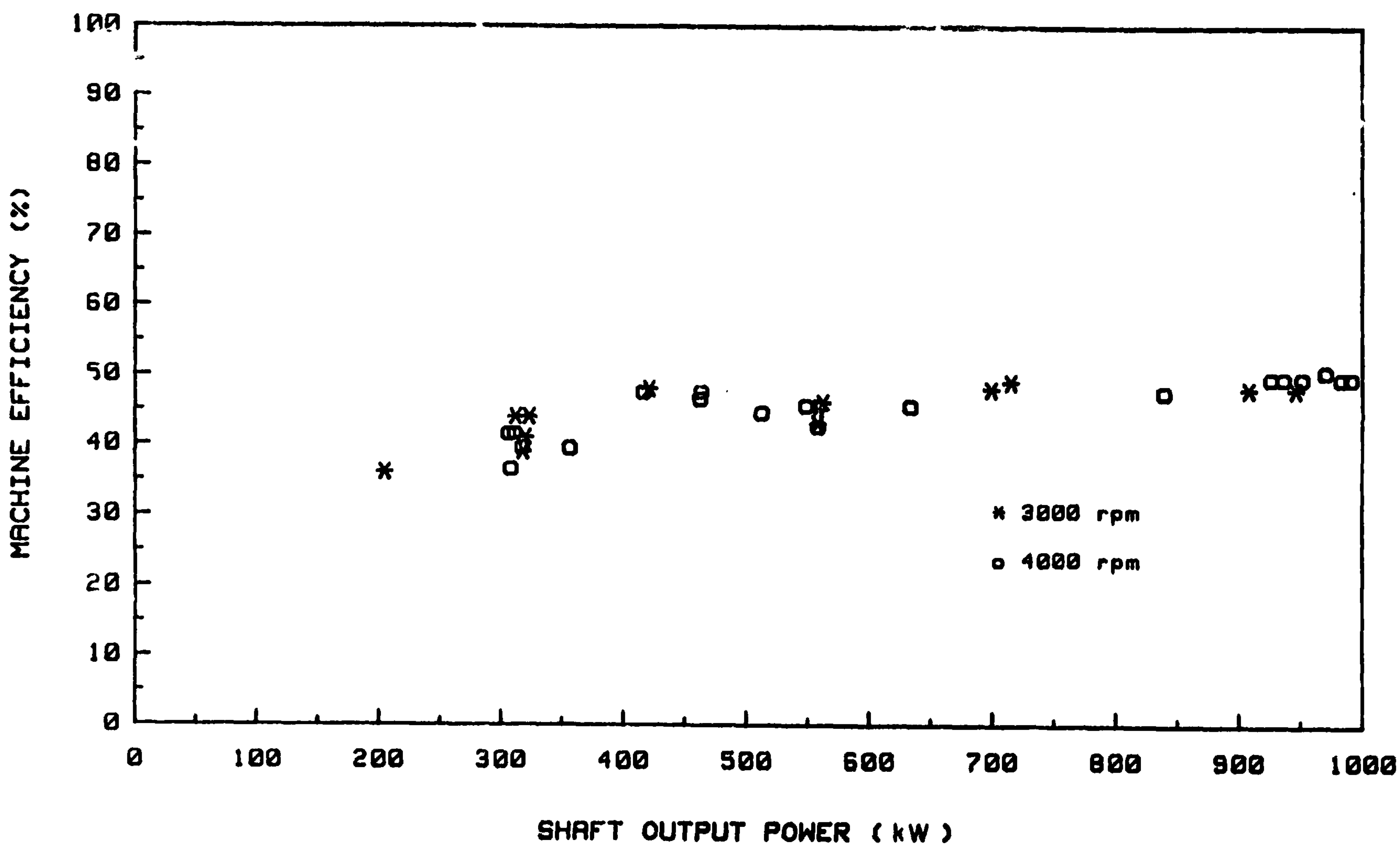

Figure A-15. Effect of Rotor Speed on Machine Efficiency for Upstream Test, All Inlet Conditions (Ref. A, Fig. 21)

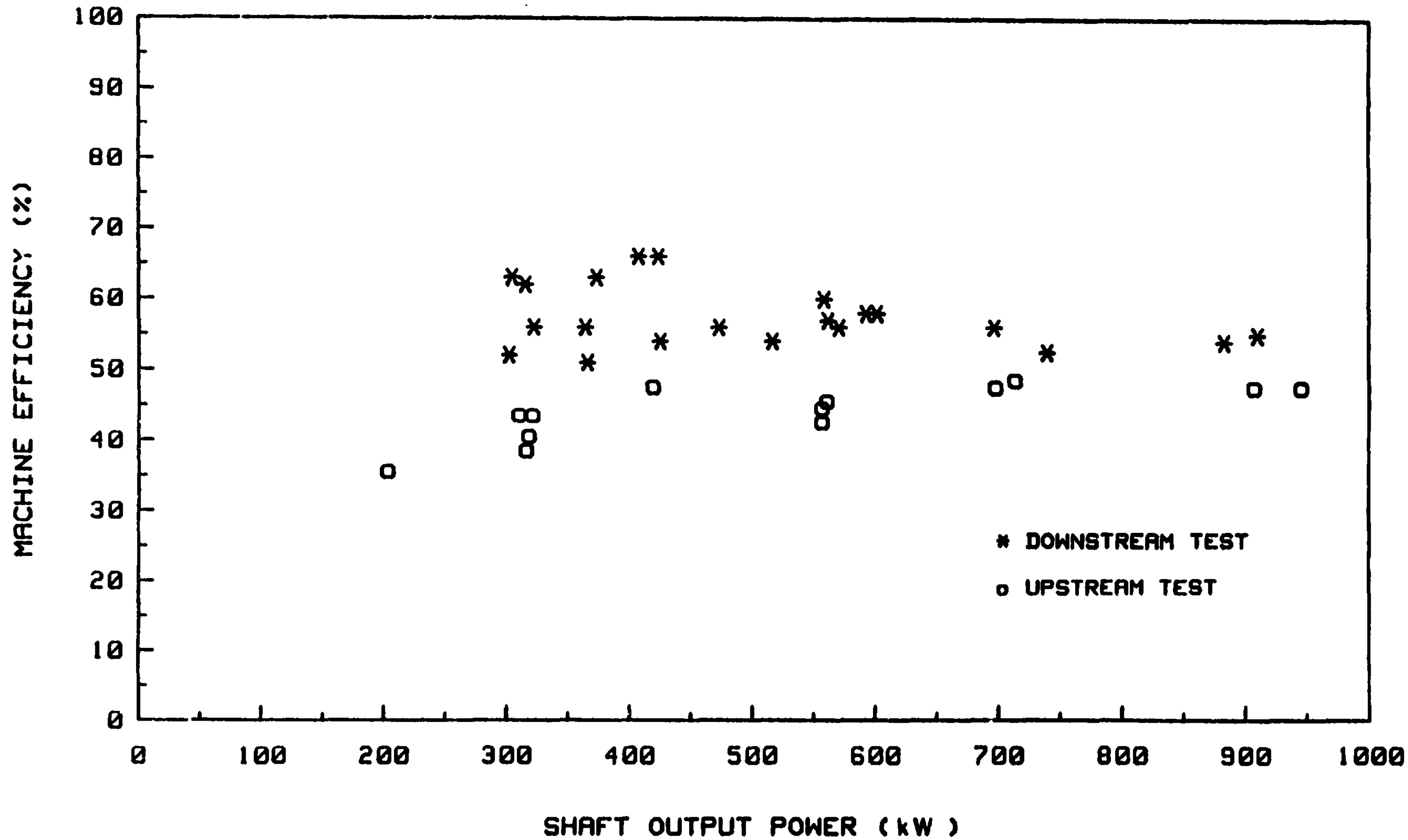

Figure A-16. Comparison Between Downstream and Upstream Tests at 3000 rpm, All Inlet Conditions (Ref. A, Fig. 22)

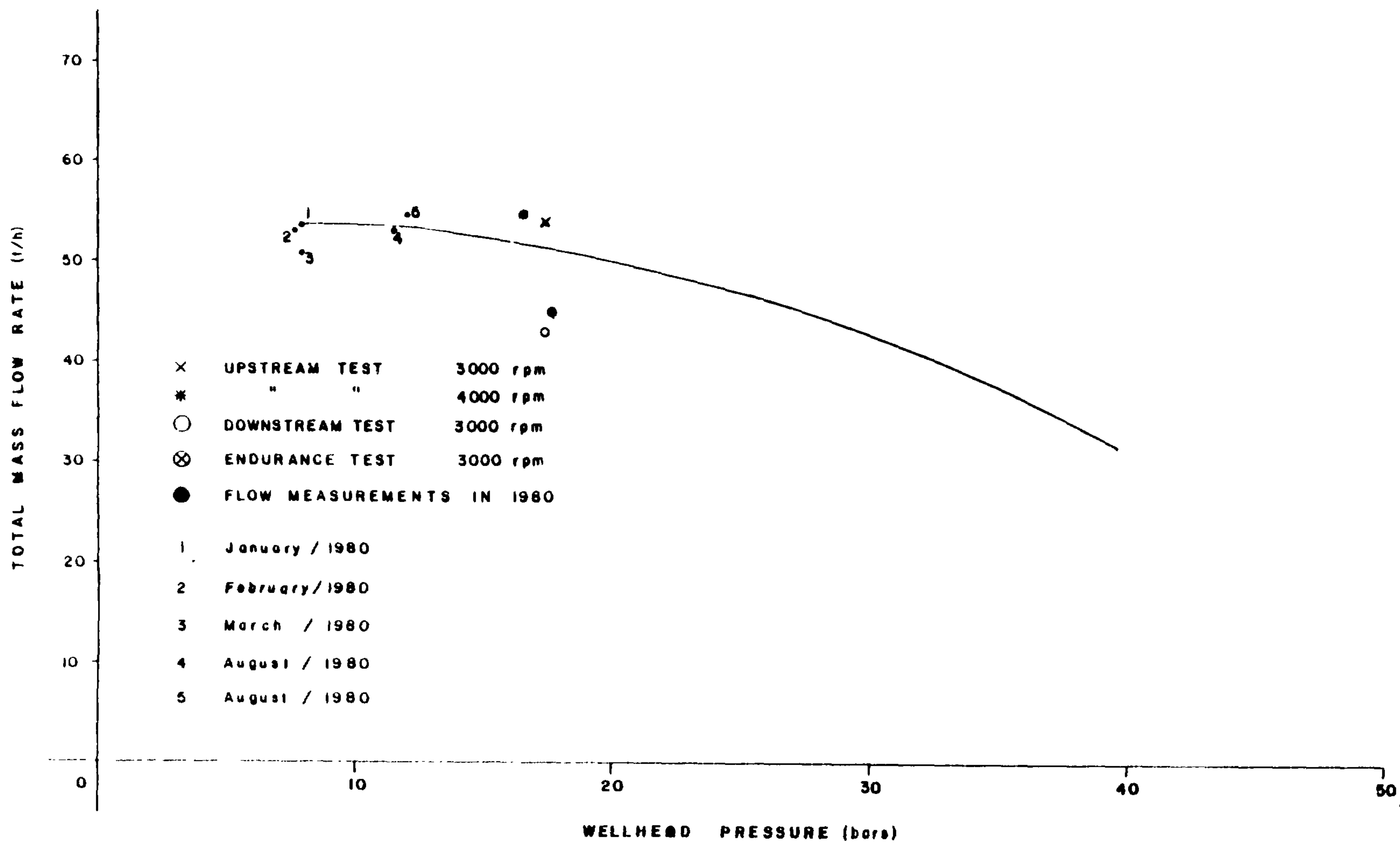

Figure A-17. Comparison Between Downstream and Upstream Measurements with the 1980 Characteristic Curve for Well M-11 (Ref. A, Fig. 24)

Table A-1. Chemical Composition of Geothermal Brine from Well M-11
(Ref. A, Table 3)

Chemical Constituent	ppm
HCO_3	49
Ca	282
Cl	9354
Na	4868
K	1125
Rb	10.48
B	10.48
SiO_2	695
Mn	0.84
Mg	0.31
Co	0.15
Cr	0.11
Li	13
CO_2	4109
H_2S	215

T.D.S. = 15,133 ppm

Table A-2. Water Chemistry of Samples Taken During the HSE Test Programme (Ref. A, Table 2)

DATE	HOUR	LOCATION	Na p.p.m. e.p.m.	K p.p.m. e.p.m.	Ca p.p.m. e.p.m.	Cl^- p.p.m. e.p.m.	HCO_3^- p.p.m. e.p.m.	Conduc- tivity mhos/cm	pH
7-IV-80	8:30	Storage pond*	198.0 8.60	14.70 0.37	34.00 1.70	329 9.30	89.10 1.50	1950 -	7.25 -
14-IV-80	8:35	Storage pond*	311 13.52	23.51 0.60	60.00 3.00	378 10.70	35 0.60	1980 -	7.00 -
5-V-80	9:00	Main container	312 13.6	43.00 1.10	69.00 3.45	601 17.00	34.50 0.60	3500 -	6.50 -
5-V-80	9:00	Main container	204 8.9	29.00 0.7	30.10 1.5	421 11.9	29.00 0.5	2500 -	6.95 -
26-VI-80	8:37	Main container	26.5	0.0	0.0	15.1	n.d.	1550	7.25
14-VII-80	8:30	Main container	6.34 0.28	0.0 0.0	3.15 0.16	49.0 1.4	n.d.	n.d.	n.d.
14-XI-80	7:50	Main container	78	1.90	3.60	70	61	-	7.18

n.d. = non determined

* = not used

TABLE A-3. NOMENCLATURE

VARIABLE	SYMBOL CFE	SYMBOL Others
Enthalpy	H	H
Output Power	kW, KW	kW, KW
Pressure	P	P
Efficiency	R	eff
Throttle Position	Thr	Trt, Tr
Mass Flow Rate	W	M
Steam Fraction	X	Q

VARIABLE	SUBSCRIPTS CFE	SUBSCRIPTS Others
Water	a	f
Inlet	e	1
Machine	m	-
Outlet	o	2
Wellhead	p	-
Total	t	-
Steam	v	v

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Table A-4. Operation and Failure Summary (Ref. A, Table 11), Part 1 of 8

DATE	TEST	START		PH		OH		GEG	FAILURE						
									HSE AND AUX. SYSTEMS			ASSOCIATED SYSTEMS			FAILURE CAUSE (OBSERVATIONS)
									F	FH		F	FH		
		S	A	S	A	S	A	A	A	S	A	A	S	A	
1980 31/3	1	1	1	6	6	0.7	0.7	0.01	1	1.5	1.5				High differential pressure in the filter of the lubrication system
2/4	2	1	2	6	12	0.1	0.8	0.01	2	3.5	5.0				High differential pressure of the lubrication system.
9/4	3	1	3	6	18	3.2	4.0	0.2	3	1.5	6.5				High differential pressure in the filter of the lubrication system
10/4	4	1	4	6	24	1.2	5.2	0.4	4	0.5	7.0				Overload in the electric system
11/4	5	1	5	6	30	1.6	6.8	0.7				1	3.5	3.5	Impurities in the water supply system
11/4	6	1	6	6	36	3.4	10.2	1.5							
15/4	7	2	8	6	42	4.4	14.6	3.3							
23/4	8	1	9	6	48	2.1	16.7	4.0							
24/4	9	1	10	6	54	3.3	20.0	4.9							
25/4	10	3	13	6	60	4.5	24.5	6.0	5	0.8					Oil leakage in safety valve

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Table A-4. Operation and Failure Summary, Part 2 of 8

DATE	TEST	START		PH		OH		GEG	FAILURE						
									HSE AND AUX. SYSTEMS			ASSOCIATED SYSTEMS			FAILURE CAUSE (OBSERVATIONS)
									F	FH		F	FH		
		S	A	S	A	S	A	A	A	S	A	A	S	A	
29/4	11	1	14	6	66	0.7	25.2	6.1	6	3.0	10.8				Oil leakage in safety valve
30/4	12	1	15	6	72	4.2	29.4	6.2							
2/5	13	1	16	6	78	4.3	33.7	8.2							
5/5	14	1	17	6	84	4.6	38.3	10.0							
6/5	15	1	18	6	90	0.8	39.1	10.3				2	3.5	7.0	Filter obstruction at unit entrance
8/5	16	2	20	6	96	1.0	40.1	10.6	7	3.5	14.3				Oil leakage in safety valve
9/5	17	2	22	6	102	3.9	44.0	12.3				3	1.0	8.0	Abnormal operation of the pneumatic control valve
12/5	18	1	23	6	108	3.7	47.7	14.3							
13/5	19	1	24	6	114	3.9	51.6	16.6							
11/5	20	1	25	6	120	3.4	55.0	18.1							

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Table A-4. Operation and Failure Summary, Part 3 of 8

DATE	TEST	START		PH		OH		GEG	FAILURE: HSE AND AUX. SYSTEMS			FAILURE: ASSOCIATED SYSTEMS			FAILURE CAUSE (OBSERVATIONS)
		S	A	S	A	S	A	A	F	FH		F	FH		
									A	S	A	A	S	A	
15/5	21	1	26	6	126	3.8	58.8	20.2							
16/5	22	1	27	6	132	3.8	62.6	22.6							
28/5	23	1	28	6	138	3.3	65.9	23.3				4	0.5	8.5	Bursting disk failure between machine and control valve
29/5	24	1	29	6	144	1.1	67.0	23.7							
30/5	25	1	30	6	150	3.0	70.0	24.9							
31/5 8/6	26	1	31	207	357	203.5	273.5	202.9				5	3.5	12.0	Precautious stop when an earthquake was present
9/6 12/6				96	453			202.9							Rotors, equipment and instruments inspection (sand)
13/6		1	32	24	477	0.9	274.4	202.9	8	3.0	17.3				Instability of differential pressure regulator
14/6 18/6	28	1	33	108	585	96.0	370.4	280.8				6	2	14	Steam leakage in pressure gage

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Table A-4. Operation and Failure Summary, Part 4 of 8

DATE	TEST	START		PH		OH		GEG	FAILURE: HSE AND AUX. SYSTEMS			FAILURE: ASSOCIATED SYSTEMS			FAILURE CAUSE (OBSERVATIONS)
									F	FH		F	FH		
		S	A	S	A	S	A	A	A	S	A	A	S	A	
18/6 26/6	29	1	34	204	789	203.4	573.8	449.5				7	0.6	14.6	Variations in the well head pressure
27/6 1/7				144	933										Well under observation. Inspection and maintenance period
2/7 8/7	30	2	36	168	1101	144.1	717.9	570.7				8	1.0	15.6	Bursting disk operates
9/7	31	2	38	24	1125	0.4	718.3	570.7				9	11.5	27.1	Overcurrent in load bank
10/7				24	1149							10	24	51.1	Unit does not start due to relay repair
11/7 15/7	32	2	40	120	1269	93.3	812.2	647.3				11	15	66.1	High well head pressure
16/7 20/7	33	3	43	120	1389	96.6	908.8	730.9				12	1	67.1	Overcurrent in load bank
21/7				24	1413			730.9							Cleannes in separated water line
22/7				24	1437										Air conditioned on mobile lab out of order
23/7 29/7	34	1	44	150	1587	140.9	1049.7	849.6							Endurance tests end

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Table A-4. Operation and Failure Summary, Part 5 of 8

DATE	TEST	START		PH		OH		GEG	FAILURE: HSE AND AUX. SYSTEMS			FAILURE: ASSOCIATED SYSTEMS			FAILURE CAUSE (OBSERVATIONS)
		S	A	S	A	S	A	A	F	FH		F	FH		
									A	S	A	A	S	A	
29/7	35	1	45	6	1539	4.2	1053.9	851.4				13	1.8	68.9	Left fan blade damage of the load bank
30/7 11/8				78	1671			851.4				14	78	146.9	Fan repair
12/8 13/8				12	1683			851.4							Data processing system printer in repair
14/8	36	1	46	6	1689	0.1	1054	851.4	9	1.5	18.8				Bad operation in a seal water system valve
15/8	37	3	49	6	1695	3.0	1057	853.0	10	1.5	20.3				Bad operation of the water and oil separation system
18/8	38	1	50	2	1697	1.7	1058.7	853.5							
20/8	39	3	53	1	1698	0.7	1059.4	853.7	11	0.3	20.6				Bad operation of the main pump of the lubrication system

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Table A-4. Operation and Failure Summary, Part 6 of 8

DATE	TEST	START S	START A	PH S	PH A	OH S	OH A	GEG A	FAILURE: HSE AND AUX. SYSTEMS F A	HSE AND AUX. SYSTEMS FH S	HSE AND AUX. SYSTEMS FH A	ASSOCIATED SYSTEMS F A	ASSOCIATED SYSTEMS FH S	ASSOCIATED SYSTEMS FH A	FAILURE CAUSE (OBSERVATIONS)
27/8	40	1	54	6.0	1704	1.9	1061.3	854.2	12	3.0	23.6				Low differential pressure in the lubrication system
28/8	41	1	55	282.0	1986	1.8	1063.1	854.8	13	280.2	303.8				Synchronization gear failure (not sufficient lubrication)
1/9 4/1															Condenser installation and Test
5/1 9/1	42	1	56	18	2004		1063.1	854.8				15	18	164.9	Basket type filter breakage at the machine inlet pipe
10/1	43	1	57	6	2010	1.3	1064.4	854.8				16	4.7	169.6	Abnormal operation of the automatic control system of the condenser level
12/1	44	1	58	6	2016	2.0	1066.4	854.8				17	4	173.6	Abnormal operation of the automatic control system of the condenser level
13/1	45	2	60	6	2022	1.7	1068.1	855.0				18	4.3	177.9	Abnormal operation of the automatic control system of the condenser level
14/1	46	1	61	6	2028	0.7	1068.8	855.1				19	5.3	183.2	Abnormal operation of the automatic control system of the condenser level
6/1 7/1				12	2040										Condenser maintenance

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Table A-4. Operation and Failure Summary, Part 7 of 8

DATE	TEST	START S	START A	PH S	PH A	OH S	OH A	GEG A	FAILURE: HSE AND AUX. SYSTEMS F A	HSE AND AUX. SYSTEMS FH S	HSE AND AUX. SYSTEMS FH A	ASSOCIATED SYSTEMS F A	ASSOCIATED SYSTEMS FH S	ASSOCIATED SYSTEMS FH A	FAILURE CAUSE (OBSERVATIONS)
8/1	17	1	62	6	2046	0.8	1069.6	855.2				20	5.2	188.4	Abnormal operation of the automatic control system of the condenser level
9/1				6	2052										Basket filter change and condenser cleanness
11/1 12/1				12	2064										Condensing system pumps out of order and computer program correction
13/1				6	2070										Auxiliary diesel plant out of order
14/1	48	3	65	6	2076	1.8	1071.4	855.7				21	4.2	192.6	Overcurrent in load bank (0.5 h). High water level in the condenser
15/1 21/1				36	2112										Condensing system equipments checked, computer program and transducers
22/1 28/1	19	1	66	30	2142	0.4	1071.8	855.7				22	29.6	222.2	Overcurrent in load bank
29/1	50	1	67	6	2148	2.9	1074.7	856.3				23	3.1	225.3	Water level control in the condenser
30/1				6	2154										Transducers and the condensing system pumps were checked
31/1	51	6	73	6	2160	0.1	1074.8	856.3				24	5.9	231.2	Bursting disk operates. Seal water pollution.

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Table A-4. Operation and Failure Summary, Part 8 of 8

DATE	TEST	START		PH		OH		GEG	FAILURE: HSE AND AUX SYSTEMS			FAILURE: ASSOCIATED SYSTEMS			FAILURE CAUSE (OBSERVATIONS)
									F	FH		F	FH		
		S	A	S	A	S	A	A	A	S	A	A	S	A	
1981 1/2				6	2166										Diesel auxiliary plant out of order
2/2	52	1	74	6	2172	4.4	1079.2	857.3				25	1.6	232.8	Abnormal operation in water level control in the condenser
3/2	53	1	75	6	2178	2.0	1081.2	858.1				26	4	236.8	Abnormal operation in water level control in the condenser
4/2	54	1	76	6	2184	1.0	1082.2	858.2				27	5	241.8	Abnormal operation in water level control in the condenser
5/2	55	1	77	6	2190	4.6	1086.8	860.5	14	1.4	305.2				Variations in the generation voltage
6/2	56	2	79	6	2196	3.7	1090.5	861.7				28	2.3	244.1	Water shortage to supply seals (1 hour). High level in condenser
7/2	57	1	80	6	2202	3.8	1094.3	862.5							
20/2	58	1	81	6	2208	6	1100.3	865.0							
	58		81		2208		1100.3	865.0	14		305.2	28		244.1	(Total accumulated data)

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Table A-5. Endurance Test Data (Ref. A, Appendix C), Part 1 of 7

HELICAL SCREW EXPANDER
ENDURANCE TEST DATA

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	He	Ho	KW	KWs	Thr	Rm	Rt
		(------psia------)			(------lbm/h-------)			(--%-)		(Btu/lb)		(--kW--)		(----%---)		
05/31/80	20:40:17	240.8	186.7	15.7	56989	37261	94250	29	40	599	566	842	895	58	50	47
05/31/80	21:43:01	240.2	179.6	15.7	56316	36793	93109	30	40	599	566	846	899	59	51	48
05/31/80	23:25:20	245.8	190.1	15.8	59025	36834	95859	28	38	587	556	836	889	57	50	47
06/01/80	00:25:53	247.7	187.0	16.0	56989	36756	93745	29	39	596	564	835	888	55	50	47
06/01/80	04:39:43	248.4	190.6	15.4	57327	36443	93770	28	39	591	559	835	888	55	50	47
06/01/80	08:29:34	250.0	176.9	15.6	57665	36759	94424	29	39	592	560	840	893	62	51	48
06/01/80	12:13:23	250.8	181.2	15.8	50713	36642	87355	33	42	624	590	830	883	60	50	47
06/01/80	18:41:17	248.4	178.7	15.4	51687	35698	87385	31	41	613	578	839	892	62	51	48
06/01/80	23:37:29	262.2	182.4	15.1	57665	36366	94031	28	39	588	556	830	883	55	50	47
06/02/80	00:11:07	259.7	185.8	16.1	56652	36834	93486	29	39	598	566	831	884	56	50	47
06/02/80	04:49:28	259.7	189.4	16.1	56316	36445	92761	29	39	597	565	828	881	53	50	47
06/02/80	09:10:05	255.9	172.5	15.2	55981	36839	92820	30	40	600	567	870	924	73	52	49
06/02/80	16:06:24	240.8	175.6	15.4	57665	36764	94429	29	39	593	560	871	925	68	52	49
06/02/80	23:12:54	238.9	184.2	14.9	58684	37108	95792	28	39	590	557	879	933	61	51	48
06/03/80	00:59:27	237.0	183.6	15.6	62127	37376	99503	27	38	579	547	874	928	61	52	49
06/03/80	05:50:15	235.8	183.3	15.5	61433	37065	98498	27	38	579	547	873	927	61	52	49
06/03/80	10:26:52	230.7	176.9	15.2	52995	36009	89004	31	40	609	574	866	919	68	52	49
06/03/80	18:03:29	245.8	173.7	15.6	56989	36994	93983	30	39	598	564	879	933	71	53	50
06/03/80	23:10:46	249.6	181.8	15.6	59025	37183	96208	29	39	590	557	877	931	65	52	49
06/04/80	01:40:59	248.3	186.1	15.6	59025	37184	96209	28	39	591	557	879	933	59	52	49
06/04/80	05:53:43	244.5	190.1	15.8	59025	36872	95897	28	38	589	556	882	936	61	52	49
06/04/80	09:37:55	245.1	173.8	16.0	54646	36756	91402	31	40	608	574	877	931	71	53	50
06/04/80	14:32:35	249.0	173.4	15.7	55312	36567	91879	31	40	603	569	875	930	76	53	50
06/04/80	19:28:23	244.6	180.8	16.0	57665	37223	94888	29	39	598	564	879	933	64	52	49
06/04/80	23:16:42	243.9	183.0	15.7	59367	36877	96244	28	38	598	554	883	937	63	53	50
06/05/80	09:55:11	238.2	175.6	15.7	58004	37261	95265	30	39	593	562	887	941	70	53	50
06/05/80	14:06:33	236.3	172.6	15.6	53324	36800	90124	32	41	614	579	881	935	76	53	50
06/05/80	18:13:52	248.4	179.3	16.2	55312	36332	91644	30	40	603	569	875	929	66	53	50
06/05/80	23:03:18	247.7	188.0	15.5	58004	37262	95266	29	39	595	562	882	936	61	51	48
06/06/80	01:22:21	246.4	187.0	15.4	58004	36795	94799	29	39	592	559	876	930	58	52	49

Table A-5. Endurance Test Data, Part 2 of 7

H E L I C A L   S C R E W   E X P A N D E R
E N D U R A N C E   T E S T   D A T A

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	He	Ho	KW	KWs	Thr	Rm	Rt
		(------	psia	------)	(------	lbm/h	-------)	(--%-)		(Btu/lb)		(--kW--)		(----	%---	)
06/06/80	04:46:17	242.0	185.2	15.4	58004	36355	94359	28	39	590	556	880	934	60	53	50
06/06/80	09:32:04	238.9	173.8	16.1	58344	36398	94742	29	38	590	556	882	936	67	55	51
06/06/80	14:20:34	243.9	175.9	15.7	54315	35362	89677	30	39	601	565	876	930	73	55	51
06/06/80	19:06:27	243.9	176.8	15.5	54979	36567	91546	30	40	604	570	876	930	67	53	50
06/06/80	23:57:56	241.4	183.6	15.7	56652	36603	93255	29	39	598	563	876	930	62	52	49
06/07/80	04:43:50	242.6	182.7	15.6	57327	36392	93719	29	39	593	559	880	934	62	53	50
06/07/80	09:29:37	238.8	177.2	15.7	56989	36085	93074	29	39	593	559	874	928	70	54	51
06/07/80	14:15:33	235.7	173.8	15.9	52667	36134	88801	32	41	614	578	874	928	69	54	50
06/07/80	23.02:12	243.2	184.6	15.9	55981	36916	92897	30	40	603	569	872	926	61	52	49
06/08/80	00:25:49	246.4	189.5	15.7	58684	36125	94809	28	38	586	552	875	929	59	53	50
06/08/80	04:04:29	245.8	187.7	16.5	57665	36756	94421	29	39	596	562	873	927	61	53	49
06/08/80	08:56:58	236.9	179.4	15.8	56652	35606	92258	29	39	592	557	874	928	68	54	51
06/14/80	12:41:26	235.8	177.5	15.9	70884	36509	107393	23	34	541	513	821	873	70	52	49
06/14/80	17:29:48	241.4	182.0	15.7	65843	35273	101116	24	35	551	521	818	870	65	53	49
06/14/80	22:15:43	245.2	186.7	15.8	66555	34749	101304	23	34	545	516	816	868	59	53	50
06/15/80	00:57:43	243.9	189.2	15.8	66912	35967	102879	24	35	551	522	810	862	57	51	48
06/15/80	04:55:48	249.0	188.9	15.8	70155	35222	105377	22	33	535	507	816	868	57	53	49
06/15/80	09:41:42	233.2	175.0	15.8	65488	35549	101137	25	35	555	525	826	878	71	53	50
06/15/80	14:28:51	234.5	177.8	15.7	62325	35366	97691	26	36	564	534	816	868	69	52	49
06/15/80	19:14:59	244.0	180.5	15.7	62674	35672	98346	26	36	565	535	817	869	64	52	48
06/16/80	01:07:40	248.4	188.5	15.8	68707	35322	104029	22	34	541	512	811	863	57	52	49
06/16/80	03:51:33	252.7	185.5	15.8	66555	36147	102702	24	35	553	524	811	863	57	51	48
06/16/80	09:32:38	234.5	175.0	15.8	67987	35357	103344	23	34	544	515	823	875	68	54	50
06/16/80	17:59:29	240.9	180.7	15.5	61630	34075	95705	25	36	559	528	813	865	60	54	50
06/16/80	22:43:14	246.5	180.2	15.7	65488	34862	100350	24	35	549	520	816	868	60	53	50
06/17/80	00:36:33	252.2	187.5	15.8	67269	35580	102849	23	35	547	519	814	866	57	52	49
06/17/80	05:20:11	244.6	186.0	15.8	69792	35770	105562	22	34	540	512	815	867	56	52	49
06/17/80	10:03:42	237.6	174.7	15.7	66555	35317	101872	24	35	548	519	816	868	70	53	50
06/17/80	14:47:19	238.3	171.5	15.7	59905	34888	94793	27	37	571	540	817	869	70	53	50
06/17/80	19:31:04	245.2	182.9	15.7	66199	34411	100610	23	34	544	515	817	869	59	54	51

Table A-5. Endurance Test Data, Part 3 of 7

HELICAL SCREW EXPANDER
ENDURANCE TEST DATA

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	He	Ho	KW	KWs	Thr	Rm	Rt
		(------psia------)			(------lbm/h-------)			(--%-)		(Btu/lb)		(--kW--)		(----%---)		
06/18/80	00:17:11	242.7	189.2	15.8	69792	34671	104463	22	33	533	505	815	867	57	53	50
06/18/80	05:00:40	252.7	183.0	15.8	69068	35818	104886	23	34	542	514	808	860	55	52	48
06/18/80	09:44:08	228.8	173.2	15.9	63023	35402	98425	26	36	562	532	820	872	72	53	50
06/18/80	13:50:45	249.6	174.7	15.8	64780	35407	100187	25	35	556	526	834	887	70	54	51
06/18/80	18:36:53	242.7	181.1	15.8	64428	36430	100858	25	36	563	533	836	889	68	52	49
06/18/80	23:31:52	245.8	187.0	15.8	68707	34868	103575	22	34	539	510	838	891	60	54	51
06/19/80	00:28:32	245.2	188.8	15.9	71615	35488	107103	22	33	533	505	831	884	61	53	50
06/19/80	05:12:10	243.9	187.0	15.7	70519	35418	105937	22	33	536	507	837	890	59	54	50
06/19/80	09:55:40	241.4	179.3	15.8	67987	34848	102835	23	34	541	512	836	889	67	55	52
06/19/80	14:45:26	239.6	181.1	15.8	61630	35602	97232	26	37	570	538	840	893	69	53	50
06/19/80	19:34:07	245.2	182.0	15.7	64075	35241	99316	25	35	558	527	837	890	63	53	50
06/20/80	01:12:43	247.7	187.0	15.9	67987	34873	102860	23	34	542	512	836	889	61	54	51
06/20/80	05:08:05	248.3	190.1	15.9	68347	35717	104064	23	34	545	516	835	888	61	53	50
06/20/80	09:55:16	245.8	180.3	15.9	65134	35516	100650	25	35	556	526	831	884	65	53	50
06/20/80	14:44:10	237.0	178.7	15.7	62325	36405	98730	27	37	571	540	840	893	71	52	49
06/20/80	19:42:12	246.5	186.0	15.8	67269	35123	102392	23	34	545	516	834	887	62	54	50
06/21/80	00:30:26	243.9	191.3	15.8	70519	34851	105370	21	33	533	504	834	887	61	54	51
06/21/80	05:13:56	250.2	185.2	15.7	70519	35022	105541	22	33	533	505	831	884	60	54	51
06/21/80	10:04:34	252.7	181.8	15.9	64428	34889	99317	24	35	554	524	831	884	66	54	51
06/21/80	14:51:09	234.5	176.2	15.8	62325	35127	97452	26	36	564	533	834	887	67	54	51
06/21/80	19:37:48	237.7	186.4	15.6	65488	35127	100615	24	35	551	521	838	891	64	53	50
06/21/80	23:45:23	243.9	186.1	15.6	66912	34906	101818	23	34	545	515	839	892	60	54	51
06/22/80	01:54:39	254.6	189.2	15.5	73085	35389	108474	21	33	527	499	837	890	61	54	50
06/22/80	05:35:17	238.3	191.9	15.8	70884	35423	106307	22	33	535	506	839	892	61	53	50
06/22/80	10:18:58	231.3	178.1	15.9	61630	35289	96919	26	36	568	536	831	884	66	53	50
06/22/80	15:14:13	244.6	181.4	16.1	64075	35002	99077	25	35	557	527	832	885	66	54	51
06/22/80	20:03:59	244.6	181.1	15.5	66199	34248	100447	23	34	543	513	831	884	63	55	52
06/23/80	00:10:21	247.7	189.4	15.9	71615	34835	106450	21	33	529	501	827	879	59	54	51
06/23/80	04:48:22	243.3	190.4	15.8	70884	34969	105853	21	33	532	504	831	884	58	54	51
06/23/80	09:33:29	231.9	182.7	15.9	63373	35471	98844	25	36	562	531	834	887	68	53	50

Table A-5. Endurance Test Data, Part 4 of 7

HELICAL SCREW EXPANDER
ENDURANCE TEST DATA

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	He	Ho	KW	KWs	Thr	Rm	Rt
		(------	psia------	)	(------	lbm/h-------	)	(--%-)		(Btu/lb)		(--kW--)		(----	%---	)
06/23/80	14:26:02	249.8	175.9	16.3	59905	35293	95198	27	37	575	544	827	879	67	53	50
06/23/80	19:22:45	257.3	181.4	15.6	62674	34382	97056	25	35	557	526	827	879	64	54	51
06/24/80	00:48:11	263.0	188.2	15.6	69430	33827	103257	21	33	529	500	825	877	57	55	52
06/24/80	04:54:57	252.9	191.3	16.0	69792	33994	103786	21	33	530	501	827	879	57	55	52
06/24/80	10:00:04	254.8	180.6	15.5	65843	34234	100077	23	34	544	514	821	873	62	54	51
06/24/80	14:39:31	239.1	179.0	15.8	65488	34801	100289	24	35	550	520	834	887	67	55	51
06/24/80	18:48:42	238.4	185.2	15.4	70519	34536	105057	21	33	529	501	825	877	63	54	51
06/24/80	23:34:15	254.2	189.5	15.8	71981	34254	106235	20	32	524	496	822	874	57	55	52
06/25/80	01:27:37	251.6	189.5	15.8	71981	34082	106063	20	32	523	495	824	876	57	55	52
06/25/80	05:17:56	252.3	192.9	15.8	74195	33620	107815	19	31	513	486	824	876	57	56	53
06/25/80	10:02:43	249.1	186.4	15.8	65134	33895	99029	23	34	545	515	816	868	60	54	51
06/25/80	14:06:47	254.8	179.3	15.5	66912	33275	100187	22	33	534	505	813	865	64	56	52
06/25/80	18:52:23	249.1	185.1	15.6	66912	33892	100804	22	34	538	509	818	870	61	55	51
06/25/80	23:36:10	260.4	194.7	15.9	63724	33466	97190	23	34	548	517	812	864	54	54	51
06/26/80	00:32:59	259.8	191.3	15.6	68707	33569	102276	21	33	530	501	808	860	56	54	51
06/26/80	05:16:45	250.4	190.1	15.8	70155	34065	104220	21	33	529	500	817	869	58	55	51
06/26/80	10:03:21	252.3	189.2	15.9	65843	33327	99170	22	34	539	509	808	860	61	55	51
06/26/80	14:49:54	255.4	179.6	15.8	70519	33383	103902	21	32	524	495	827	879	64	57	54
06/26/80	18:59:24	257.9	184.2	15.6	65843	33226	99069	22	34	538	508	822	874	59	56	53
06/26/80	23:11:10	254.2	183.9	15.7	70155	33383	103538	21	32	524	496	821	873	61	56	53
07/02/80	12:14:21	254.2	188.3	15.9	62829	34060	96889	24	35	556	524	837	890	59	55	52
07/02/80	17:11:05	256.0	184.0	16.0	62036	34761	96797	25	36	564	532	849	902	61	55	52
07/02/80	22:00:58	259.8	195.0	16.0	62333	35222	97555	25	36	565	534	847	900	58	53	50
07/03/80	01:55:06	264.8	195.7	16.0	64826	35080	99906	24	35	555	524	840	893	55	53	50
07/03/80	05:39:41	260.4	195.7	16.0	59000	35393	94393	27	37	580	547	843	896	52	52	49
07/03/80	10:31:03	260.4	183.3	15.9	67762	33833	101595	22	33	537	506	848	901	61	57	54
07/03/80	15:07:43	256.7	182.4	16.0	63525	34808	98333	25	35	558	527	849	902	67	55	52
07/04/80	01:52:39	271.1	194.1	15.9	61543	34490	96033	25	36	563	532	837	890	-	54	50
07/04/80	05:13:50	277.4	189.8	15.9	62432	34077	96509	24	35	557	526	835	888	-	55	51
07/04/80	09:22:30	272.4	190.1	15.9	65329	34111	99440	23	34	547	516	839	892	-	55	52

Table A-5. Endurance Test Data, Part 5 of 7

HELICAL SCREW EXPANDER
ENDURANCE TEST DATA

3000 rpm

DATE	TIME	Po	Pe	Po	Wa	Wv	Wt	Xe	Xo	He	Ho	KW	KWs	Thr	Rm	Rt
		(------psia------)			(------lbm/h-------)			(--%-)		(Btu/lb)		(--kW--)		(----%---)		
07/04/80	14:00:55	259.8	185.1	16.1	63525	34126	97651	24	35	554	523	848	901	56	56	53
07/04/80	19:09:29	256.7	182.6	15.8	64325	34008	98333	24	35	550	519	843	896	56	56	53
07/04/80	22:54:24	263.6	189.7	16.1	61248	34146	95394	25	36	563	531	841	894	52	55	52
07/05/80	13:59:22	249.8	177.8	15.8	64726	34094	98820	24	35	549	518	849	902	60	57	53
07/05/80	09:44:09	257.3	186.1	15.8	63925	34161	98086	24	35	552	521	847	900	56	56	52
07/05/80	22:29:44	259.8	188.9	15.8	66541	35552	102093	22	33	551	521	849	902	50	59	55
07/05/80	18:14:33	264.2	186.6	15.8	63127	33169	96296	24	34	549	517	840	893	-	57	53
07/06/80	03:22:42	264.2	194.1	16.1	62531	32700	95231	23	34	549	517	843	896	-	57	54
07/06/80	05:48:45	261.7	191.6	16.0	60953	33921	94874	25	36	563	530	848	901	50	55	52
07/06/80	10:13:44	261.7	179.6	16.8	62135	33115	95250	25	35	555	523	850	903	-	59	55
07/06/80	14:40:22	260.4	186.7	15.7	62630	34739	97369	25	36	560	529	847	900	-	54	51
07/06/80	18:55:35	257.9	185.1	15.3	66744	33488	100232	22	33	537	506	853	906	-	57	54
07/06/80	23:10:48	263.6	189.4	16.0	65732	33800	99532	23	34	544	513	850	903	-	57	53
07/07/80	01:11:58	266.1	194.4	16.7	62730	32921	95651	23	34	551	519	846	899	54	58	54
07/07/80	04:20:17	267.4	193.2	15.4	62829	33588	96417	24	35	552	520	849	902	49	55	52
07/07/80	09:13:47	260.4	187.3	16.8	65732	33626	99358	23	34	545	514	853	906	57	58	55
07/07/80	15:35:57	263.6	186.0	15.7	64425	33610	98035	23	34	547	515	844	897	54	56	53
07/11/80	12:20:07	254.8	181.5	15.9	60926	34896	95822	26	36	568	537	819	871	-	53	50
07/11/80	15:13:51	263.0	180.5	16.0	56852	34973	91825	28	38	585	553	817	869	-	52	49
07/11/80	18:22:39	260.4	182.7	15.7	56948	35003	91951	28	38	584	552	822	874	-	51	48
07/11/80	22:34:39	264.0	186.0	15.8	54005	35097	89102	29	39	599	565	822	874	-	51	48
07/12/80	03:07:39	263.0	191.3	16.1	57723	35249	92972	30	40	584	552	822	874	-	51	48
07/12/80	06:10:39	249.1	187.6	16.0	54854	35343	90197	29	39	597	564	829	882	-	52	48
07/12/80	10:25:39	250.4	185.5	15.9	55043	35257	90300	29	39	595	562	824	876	-	51	48
07/12/80	14:19:39	250.4	185.5	15.9	55043	35257	90300	29	39	595	562	824	876	-	51	48
07/12/80	19:04:39	257.9	185.2	15.8	50854	35277	86131	29	39	615	580	823	875	-	51	48
07/13/80	00:25:41	257.9	188.3	15.9	56661	35252	91913	28	38	588	555	827	879	-	52	48
07/13/80	05:37:41	259.2	191.7	15.9	55802	34982	90784	28	39	590	557	823	875	-	51	48
07/13/80	10:58:41	251.0	185.2	15.8	57332	35216	92548	28	38	584	552	824	876	-	52	49
07/13/80	16:52:41	261.7	184.6	15.8	57524	34570	92094	27	38	580	547	824	876	-	53	50

Table A-5. Endurance Test Data, Part 6 of 7

HELICAL SCREW EXPANDER
ENDURANCE TEST DATA

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	He	Ho	KW	KWs	Thr	Rm	Rt
		(------psia------)			(------lbm/h-------)			(--%-)		(Btu/lb)		(--kW--)		(----%---)		
07/13/80	23:49:41	261.1	190.7	15.9	53068	34387	87455	29	39	599	565	825	877	-	52	49
07/14/80	01:01:41	257.3	189.5	15.8	55138	34575	89713	28	39	590	557	822	874	53	52	49
07/14/80	08:13:39	265.5	183.6	15.9	56279	34129	90408	28	38	582	549	818	870	54	53	50
07/14/80	12:18:04	252.3	181.8	16.0	63028	[illegible]	98316	25	36	562	532	825	877	58	53	50
07/14/80	16:48:04	250.4	181.5	15.8	64826	34488	99314	24	35	550	520	820	872	59	54	51
07/14/80	21:18:04	252.3	190.7	15.8	62234	34077	96311	24	35	557	526	823	875	52	54	50
07/15/80	01:51:05	251.0	191.6	15.7	59973	34606	94579	26	37	569	538	822	874	-	52	49
07/15/80	04:48:05	257.3	195.3	15.7	60169	34008	94177	25	36	565	533	819	871	51	53	50
07/16/80	13:11:10	266.7	183.6	15.9	71056	36185	107241	23	34	540	511	859	912	59	54	51
07/16/80	16:37:04	256.7	184.2	15.8	62730	36631	99361	26	36	573	541	878	932	63	55	52
07/16/80	19:23:04	259.2	185.4	15.7	70848	35982	106830	22	34	539	510	875	929	58	55	52
07/16/80	23:31:04	263.0	188.6	15.3	68068	36093	104161	23	35	548	518	875	929	56	54	51
07/17/80	01:09:05	261.7	194.7	15.6	68785	35916	104701	23	34	545	515	874	928	53	54	51
07/17/80	05:49:05	266.1	193.7	15.7	62531	37158	99689	26	37	576	544	876	930	55	51	48
07/17/80	10:29:05	262.3	185.2	16.3	69505	35659	105164	23	34	543	513	872	926	59	56	53
07/17/80	14:57:21	259.2	183.5	16.7	66035	36262	102297	25	35	560	529	877	931	62	55	52
07/17/80	19:37:21	257.3	190.9	15.0	70124	35763	105887	22	34	538	509	871	925	56	54	51
07/18/80	00:37:21	259.2	196.2	16.1	67456	36629	104085	24	35	556	525	880	934	53	53	50
07/18/80	07:17:21	265.5	191.0	14.7	62333	36028	98361	25	37	567	536	864	917	52	52	49
07/18/80	13:07:43	251.6	187.0	16.1	64726	36693	101419	26	36	566	535	873	927	62	53	50
07/18/80	17:33:43	256.0	191.6	15.8	63127	36491	99618	26	37	570	538	871	925	56	53	50
07/18/80	22:11:43	261.1	189.4	16.1	67864	36186	104050	24	35	551	521	872	926	57	54	51
07/19/80	00:41:44	263.6	190.4	15.9	65530	36113	101643	25	36	559	528	871	925	-	54	51
07/19/80	05:11:44	268.6	197.1	15.8	64325	35370	99695	24	35	559	527	866	919	51	54	51
07/19/80	09:49:44	259.2	189.5	16.1	66541	36831	103372	25	36	560	529	867	920	55	53	50
07/19/80	14:01:44	247.2	184.8	15.8	68068	36496	104564	24	35	552	522	876	930	62	54	51
07/20/80	01:24:29	253.5	194.3	15.9	67762	35970	103732	23	35	550	520	873	927	53	54	51
07/20/80	05:14:29	266.7	196.2	15.9	65430	36003	101433	24	35	559	528	866	919	50	53	50
07/20/80	09:54:29	253.5	188.2	15.9	68273	36048	104321	23	35	549	519	874	928	59	54	51
07/23/80	09:42:20	210.8	177.8	15.6	63127	31997	95124	23	34	539	509	780	831	50	56	52

Table A-5. Endurance Test Data, Part 7 of 7

HELICAL SCREW EXPANDER
ENDURANCE TEST DATA

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	He	Ho	KW	KWs	Thr	Rm	Rt
		(------psia------)			(------lbm/h-------)			(--%-)		(Btu/lb)		(--kW--)		(----%---)		
07/23/80	14:32:40	264.2	183.6	15.6	65128	34979	100107	24	35	552	521	840	893	55	54	51
07/23/80	19:12:40	264.8	188.8	15.7	62234	35502	97736	25	36	566	535	839	892	54	52	49
07/23/80	23:52:40	266.7	190.7	15.7	66541	34883	101424	23	34	547	517	846	899	49	54	51
07/24/80	01:04:41	268.6	191.6	15.7	65833	35219	101052	24	35	551	521	846	899	-	53	50
07/24/80	04:32:41	262.3	190.9	15.8	65228	35700	100928	24	35	557	526	853	906	52	53	50
07/24/80	08:55:50	259.2	183.0	15.9	64225	35868	100093	25	36	562	531	852	905	59	53	50
07/24/80	13:19:37	252.9	181.7	15.8	66846	35767	102613	24	35	551	521	856	909	60	54	51
07/24/80	20:38:20	254.2	186.3	15.7	72933	35200	108133	21	33	527	499	861	914	55	56	53
07/25/80	00:08:20	258.6	190.3	15.8	62531	35979	98510	26	37	569	537	855	908	54	53	49
07/25/80	05:23:20	259.2	186.0	15.7	62730	34042	96772	24	35	556	524	853	906	53	56	53
07/25/80	10:32:20	256.7	183.9	15.7	69917	35242	105159	22	34	537	508	853	906	55	55	52
07/25/80	14:58:44	259.8	181.4	15.7	68273	35159	103432	23	34	542	512	852	905	58	55	52
07/25/80	19:33:15	245.3	185.4	15.8	67966	35131	103097	23	34	543	514	847	900	57	55	51
07/26/80	00:57:53	256.7	191.6	15.7	64926	34852	99778	24	35	552	522	841	894	51	54	50
07/26/80	06:12:53	260.4	190.7	15.8	65128	34883	100011	24	35	552	521	834	887	50	53	50
07/26/80	10:56:40	258.6	181.5	15.7	65128	34404	99532	24	35	548	518	831	884	56	55	51
07/26/80	15:07:52	258.6	183.6	15.6	67252	34574	101826	23	34	541	512	830	883	52	54	51
07/26/80	20:19:52	248.5	188.5	15.6	64826	34586	99412	24	35	551	520	836	889	49	54	51
07/27/80	00:33:53	263.0	190.4	15.8	64124	35483	99607	25	36	559	529	844	897	54	53	50
07/27/80	05:48:53	261.1	195.6	15.7	65732	35510	101242	24	35	553	523	845	898	49	53	49
07/27/80	10:06:53	260.4	182.7	15.8	64525	35265	99790	25	35	557	526	847	900	57	54	51
07/27/80	15:12:53	255.4	181.7	15.7	67762	35060	102822	23	34	543	514	849	902	60	55	52
07/27/80	19:43:53	252.3	186.3	15.7	68785	35015	103800	22	34	540	510	846	899	55	55	51
07/27/80	23:51:21	259.8	187.9	15.7	68682	35674	104356	23	34	544	514	856	909	57	54	51
07/28/80	01:01:21	259.8	189.1	15.5	67049	34507	101556	23	34	543	512	858	911	52	55	52
07/28/80	05:27:21	261.1	189.4	15.7	65027	35690	100717	24	35	557	527	850	903	52	53	50
07/28/80	23:34:56	261.7	189.1	15.8	65936	35322	101258	24	35	552	522	856	909	-	54	51
07/29/80	00:34:56	259.8	190.0	15.9	65532	36331	101863	25	36	560	529	855	908	52	53	49
07/29/80	01:19:56	257.3	189.4	15.9	69198	35410	104608	23	34	541	512	856	909	55	55	51

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm (Ref. A, Appendix D), Part 1 of 11

HELICAL SCREW EXPANDER
2ND PERFORMANCE TEST DATA
ATMOSPHERIC EXHAUST PRESSURE

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-------)	(----------	lbm/h	----------)	(--%-)		(kW)	(----%---		---)
07/29/80	06:53:17	237.8	107.2	14.9	43613.0	13725.0	57338.0	14	24	270	39	63	55
07/29/80	06:56:47	240.3	103.5	14.8	45279.0	14191.0	59470.0	15	24	273	43	63	54
07/29/80	06:57:47	200.1	87.4	14.8	44663.0	15343.0	60006.0	18	26	272	66	62	54
07/29/80	06:59:00	206.4	99.5	14.8	45987.0	14714.0	60701.0	15	24	273	51	62	53
07/29/80	07:10:00	195.7	101.6	14.8	56784.0	14643.0	71427.0	11	21	265	46	63	55
07/29/80	07:28:16	191.3	95.1	14.8	52349.0	15050.0	67400.0	13	22	265	50	61	53
07/29/80	07:30:55	190.6	93.3	14.9	54598.0	15038.0	69636.0	13	22	265	59	63	54
07/29/80	07:35:40	194.4	92.1	14.8	52535.0	14686.0	67261.0	13	22	264	59	64	55
07/29/80	07:49:35	183.7	101.6	14.9	54692.0	17290.0	71982.0	15	24	329	59	62	54
07/29/80	07:50:05	176.2	104.7	14.9	53844.0	16472.0	70316.0	14	23	329	57	64	57
07/29/80	07:50:35	180.6	99.8	15.0	58807.0	17268.0	76075.0	13	23	335	64	64	57
07/29/80	08:13:36	165.5	97.3	15.0	57072.0	18640.0	75711.0	16	25	384	81	66	59
07/29/80	08:20:42	166.7	100.7	15.0	56880.0	18643.0	75523.0	16	25	386	87	65	59
07/29/80	08:26:31	169.2	96.1	15.0	55355.0	18815.0	74170.0	17	25	383	81	65	59
07/29/80	08:27:54	163.0	95.8	15.0	59682.0	18677.0	78359.0	15	24	383	80	67	60
07/29/80	08:33:54	164.2	104.1	15.0	55355.0	17785.0	73139.0	15	24	362	64	64	57
07/29/80	08:34:24	171.8	93.3	14.9	60170.0	17750.0	77920.0	14	23	362	77	69	61
07/29/80	09:03:46	198.8	138.0	14.8	54221.0	15606.0	69827.0	10	22	264	31	52	45
07/29/80	09:11:31	193.1	140.4	14.9	54315.0	15461.0	69775.0	10	22	262	30	52	45
07/29/80	09:19:53	195.0	138.0	14.8	53563.0	15242.0	68805.0	10	22	263	30	53	46
07/29/80	09:23:01	195.7	140.5	14.9	56211.0	15820.0	72031.0	10	22	262	27	51	44
07/29/80	10:03:47	205.7	142.3	15.1	59488.0	23146.0	82634.0	17	28	512	49	58	53
07/29/80	10:13:24	207.0	139.3	15.2	59585.0	22399.0	81983.0	17	27	512	50	61	56
07/29/80	10:20:55	207.0	144.2	15.2	60366.0	22567.0	82933.0	16	27	512	49	60	55
07/29/80	10:30:55	205.7	139.9	15.1	58711.0	21847.0	80558.0	17	27	513	49	62	57
07/29/80	11:00:44	240.3	181.8	15.2	56306.0	21785.0	78091.0	15	28	512	35	57	53
07/29/80	11:01:46	238.4	180.9	15.2	57168.0	21919.0	79087.0	15	28	511	32	57	52
07/29/80	11:02:48	240.9	176.3	15.3	58614.0	23031.0	81645.0	16	28	514	33	55	51
07/29/80	11:04:14	241.6	177.2	15.1	56020.0	21607.0	77627.0	15	28	514	34	58	54
07/29/80	11:04:44	232.8	176.0	15.4	59293.0	23492.0	82785.0	16	28	552	34	57	53

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 2 of 11

HELICAL SCREW EXPANDER
2ND PERFORMANCE TEST DATA
ATMOSPHERIC EXHAUST PRESSURE

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-------)	(----------	lbm/h	----------)	(--%-	-)	(kW)	(----	%	---)
07/29/80	11:05:14	236.5	170.4	15.1	57360.0	22829.0	80188.0	17	28	552	37	59	55
07/29/80	11:05:44	235.3	164.5	15.3	60170.0	23900.0	84071.0	17	28	552	41	57	53
07/29/80	11:06:14	237.2	160.8	15.3	63029.0	23857.0	86886.0	16	27	550	41	58	54
07/29/80	11:08:14	230.3	152.2	15.2	59196.0	23957.0	83153.0	18	29	553	43	58	54
07/29/80	11:08:44	230.9	150.7	15.2	60073.0	23957.0	84030.0	18	29	551	48	59	54
07/29/80	11:09:14	233.4	148.2	15.3	59682.0	24488.0	84170.0	18	29	553	46	58	53
07/29/80	11:09:44	234.0	156.2	15.3	61446.0	24206.0	85652.0	17	28	551	42	58	53
08/15/80	12:47:26	200.1	114.6	14.8	30553.0	14485.0	45038.0	24	32	277	40	55	48
08/15/80	12:48:02	201.9	113.0	14.8	30630.0	14340.0	44971.0	23	32	277	41	56	49
08/15/80	12:48:38	203.2	107.5	14.8	32651.0	14614.0	47265.0	23	31	277	42	57	49
08/15/80	12:48:56	196.9	120.7	14.9	33282.0	14297.0	47579.0	21	30	277	37	56	49
08/15/80	12:49:58	201.9	109.9	14.9	34477.0	16817.0	51294.0	25	33	326	50	56	50
08/15/80	12:50:08	196.3	117.6	14.8	36337.0	16781.0	53118.0	23	32	325	42	55	49
08/15/80	12:50:26	205.1	110.3	14.8	3568[illegible].0	16874.0	52560.0	24	32	326	47	56	50
08/15/80	12:50:44	200.1	131.5	14.8	35848.0	16945.0	52973.0	22	32	325	35	[illegible]	46
08/15/80	12:51:02	194.4	142.9	14.9	36828.0	16706.0	53534.0	21	31	326	31	52	46
08/15/80	12:51:20	209.5	148.2	14.8	35848.0	16817.0	52666.0	21	32	325	28	50	44
08/15/80	12:52:32	205.7	144.5	14.9	38732.0	17784.0	56516.0	21	31	384	35	56	50
08/15/80	12:53:08	204.5	140.1	14.9	38149.0	19089.0	57238.0	24	33	382	38	52	46
08/15/80	12:53:26	201.3	145.1	14.9	38398.0	18009.0	56407.0	22	32	384	34	55	49
08/15/80	12:53:44	204.5	141.4	15.0	40499.0	18815.0	59315.0	22	32	383	36	53	48
08/15/80	12:54:20	201.9	140.2	15.0	39570.0	20486.0	60056.0	25	34	431	41	53	48
08/15/80	12:54:38	195.0	138.9	15.0	39654.0	19082.0	58736.0	23	32	431	41	58	52
08/15/80	12:54:56	197.5	139.5	15.0	40584.0	19700.0	60284.0	23	33	431	41	56	51
08/15/80	12:55:14	205.7	142.0	15.0	39234.0	19320.0	58554.0	23	33	431	39	56	51
08/15/80	12:56:26	198.2	133.7	15.1	40160.0	21972.0	62132.0	27	35	472	46	55	50
08/15/80	12:57:02	212.6	136.8	15.2	41865.0	21832.0	63696.0	25	34	472	44	55	50
08/15/80	12:58:32	216.4	139.9	15.2	42209.0	22105.0	64313.0	25	34	473	45	54	49
08/15/80	12:59:08	192.5	133.4	15.1	42123.0	22787.0	64909.0	26	35	472	5[illegible]	53	48
08/15/80	13:04:50	192.5	136.4	15.1	49385.0	23963.0	73348.0	23	33	5[illegible]0	55	56	52

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 3 of 11

HELICAL SCREW EXPANDER
2ND PERFORMANCE TEST DATA
ATMOSPHERIC EXHAUST PRESSURE

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------	psia-------	)	(----------	lbm/h----------	)	(--%-)		(kW)	(----%---)		
08/15/80	13:05:26	196.9	148.5	15.2	48477.0	23314.0	71791.0	23	32	530	49	56	52
08/15/80	13:05:44	197.5	145.4	15.2	48565.0	24368.0	72956.0	24	33	530	51	54	50
08/15/80	13:06:20	202.6	144.4	15.2	49658.0	23390.0	73048.0	22	32	531	49	57	52
08/15/80	13:36:44	212.0	144.1	15.4	54955.0	28534.0	83490.0	25	34	650	68	56	52
08/15/80	13:44:42	213.9	140.7	15.3	53918.0	28860.0	82779.0	26	35	648	70	55	52
08/15/80	13:49:11	213.3	144.4	15.5	54012.0	27996.0	82008.0	25	34	650	71	57	53
08/15/80	13:54:43	215.8	138.9	15.3	53918.0	28636.0	82554.0	26	35	649	71	56	[illegible]
08/15/80	13:58:07	208.2	172.5	15.5	54012.0	30117.0	84129.0	25	36	699	50	53	50
08/15/80	13:58:31	205.7	176.2	15.5	54672.0	30491.0	85163.0	25	36	698	49	52	49
08/15/80	14:13:33	252.3	179.9	15.9	58206.0	34301.0	95507.0	27	37	836	62	55	51
08/15/80	14:14:33	253.5	178.3	16.0	59856.0	35222.0	95078.0	27	37	830	64	53	50
08/15/80	14:15:33	254.8	177.4	16.0	60345.0	35085.0	95430.0	27	37	834	63	54	51
08/15/80	14:16:33	253.5	177.7	15.9	59175.0	34947.0	94122.0	27	37	843	63	54	51
08/15/80	14:28:26	244.1	173.7	15.9	59974.0	36040.0	95994.0	28	38	858	67	54	51
08/15/80	14:32:13	242.8	175.2	15.8	60639.0	36292.0	96930.0	28	37	859	66	53	50
08/15/80	14:35:43	240.9	174.9	15.9	54175.0	35914.0	95089.0	28	38	856	64	54	51
08/15/80	14:49:14	240.9	175.0	16.0	61031.0	34983.0	96014.0	26	36	859	68	56	52

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 4 of 11

HELICAL SCREW EXPANDER
2ND PERFORMANCE TEST DATA
ATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------	psia	-------)	(----------	lbm/h	----------)	(--	%-)	(kW)	(----	%	---)
08/28/80	09:38:02	183.7	99.9	15.0	40924.0	15767.0	56691.0	19	28	261	-	54	46
08/28/80	09:40:16	183.7	98.0	15.0	42381.0	16234.0	58615.0	19	28	261	-	53	46
08/28/80	09:41:56	182.4	96.2	15.1	43246.0	16026.0	59272.0	19	27	261	-	55	47
08/28/80	09:43:22	181.2	101.4	14.9	41951.0	15584.0	57534.0	18	27	261	-	55	47
08/28/80	09:46:23	193.	104.8	15.1	41779.0	20238.0	62017.0	25	33	376	-	55	49
08/28/80	09:46:36	193.8	105.7	15.2	42899.0	19458.0	62357.0	23	31	376	-	57	51
08/28/80	09:46:43	193.8	103.0	15.1	42209.0	20012.0	62220.0	24	32	377	-	56	50
08/28/80	09:46:49	193.8	99.6	15.1	44030.0	20801.0	64831.0	24	32	377	-	55	49
08/28/80	09:47:27	192.5	100.8	15.2	43420.0	20958.0	64378.0	25	33	394	-	57	51
08/28/80	09:47:34	189.4	103.0	15.2	43681.0	20661.0	64342.0	24	32	394	-	57	51
08/28/80	09:47:40	191.9	103.3	15.3	44907.0	20451.0	65358.0	23	31	394	-	58	52
08/28/80	09:47:47	193.1	105.1	15.2	44819.0	20849.0	65668.0	24	32	392	-	56	50
08/28/80	09:56:44	196.2	99.0	15.2	44030.0	21638.0	65669.0	26	33	425	-	59	53
08/28/80	09:58:52	186.2	101.4	15.4	43594.0	21474.0	65068.0	26	33	426	-	59	53
08/28/80	09:59:48	188.7	100.5	15.2	44732.0	21466.0	66198.0	25	32	425	-	59	53
08/28/80	10:01:12	185.6	100.8	15.1	44732.0	21510.0	66241.0	25	32	425	-	59	53
08/28/80	10:06:01	177.4	102.9	15.1	43420.0	19117.0	62537.0	22	31	358	-	57	50
08/28/80	10:06:14	173.0	105.1	15.1	44556.0	19502.0	64058.0	22	30	358	-	55	49
08/28/80	10:06:20	173.6	107.2	15.0	43073.0	20157.0	63229.0	24	32	358	-	53	47
08/28/80	10:06:27	171.8	113.1	15.1	41951.0	19489.0	61440.0	23	32	359	-	53	47
08/28/80	10:06:33	169.2	124.5	15.1	41951.0	18790.0	60740.0	22	31	358	-	53	47
08/28/80	10:08:11	174.9	132.5	15.0	42986.0	17541.0	60527.0	19	29	307	-	50	43
08/28/80	10:08:31	178.0	134.7	15.0	42726.0	17612.0	60338.0	19	29	307	-	49	43
08/28/80	10:08:43	176.2	135.9	15.0	42986.0	18151.0	61137.0	19	30	306	-	47	41
08/28/80	10:08:50	177.4	132.9	15.0	42209.0	17488.0	59697.0	19	29	308	-	50	43
08/28/80	10:13:21	175.5	136.6	15.0	39234.0	17700.0	56933.0	21	31	271	-	43	37
08/28/80	10:13:53	173.6	135.6	15.0	40584.0	17857.0	58441.0	20	31	273	-	43	37
08/28/80	10:14:53	174.9	135.9	15.0	39486.0	17255.0	56741.0	20	30	270	-	44	38
08/28/80	10:15:06	173.6	136.9	15.0	39570.0	17219.0	56789.0	20	30	271	-	45	38
08/28/80	10:21:59	170.5	139.3	15.0	38565.0	16041.0	54606.0	19	29	271	-	48	41

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 5 of 11

H E L I C A L   S C R E W   E X P A N D E R
2ND   P E R F O R M A N C E   T E S T   D A T A
ATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-------)	(----------	lbm/h	----------)	(--%	-)	(kW)	(----	%	---)
08/28/80	10:23:39	176.2	137.8	14.9	39738.0	15703.0	55442.0	17	28	271	-	49	42
08/28/80	10:26:29	174.3	138.1	15.1	40414.0	15759.0	56173.0	17	28	270	-	49	42
08/28/80	10:27:37	173.6	137.2	15.0	39318.0	16267.0	55584.0	19	29	270	-	47	41
08/28/80	10:29:12	171.1	131.0	15.1	40245.0	19972.0	60217.0	24	33	373	-	50	45
08/28/80	10:29:18	172.4	132.2	15.1	40754.0	18790.0	59544.0	22	32	374	-	54	48
08/28/80	10:29:25	166.7	132.9	15.1	41009.0	19572.0	60582.0	23	32	373	-	51	46
08/28/80	10:29:57	176.2	133.5	15.2	39570.0	21828.0	61398.0	27	36	416	-	50	45
08/28/80	10:30:03	172.4	133.8	15.3	42123.0	21816.0	63938.0	25	34	415	-	50	45
08/28/80	10:30:10	175.5	133.2	15.2	40839.0	20622.0	61461.0	24	34	414	-	53	48
08/28/80	10:30:22	174.9	131.9	15.2	41693.0	21008.0	62701.0	24	34	414	-	52	47
08/28/80	10:31:16	181.2	135.9	15.3	43768.0	22013.0	65781.0	24	33	469	-	55	50
08/28/80	10:31:29	179.9	133.8	15.3	43681.0	23050.0	66731.0	26	35	469	-	53	48
08/28/80	10:31:42	179.3	132.9	15.3	43246.0	22832.0	66078.0	26	35	469	-	53	49
08/28/80	10:31:48	179.9	134.4	15.4	44380.0	23000.0	67381.0	25	34	469	-	53	48
08/28/80	10:38:56	191.3	138.7	15.2	46859.0	24416.0	71274.0	25	34	503	-	52	48
08/28/80	10:39:09	188.7	139.3	15.4	46057.0	24491.0	70548.0	25	35	503	-	52	48
08/28/80	10:39:47	189.4	141.5	15.4	45437.0	24516.0	69953.0	26	35	503	-	52	47
08/28/80	10:40:00	191.9	140.9	15.3	45084.0	24139.0	69222.0	26	35	503	-	53	48
08/28/80	10:51:04	198.8	137.8	15.5	50573.0	29312.0	79886.0	28	37	636	-	54	50
08/28/80	10:51:29	196.9	138.7	15.5	47396.0	29052.0	76448.0	30	38	637	-	54	50
08/28/80	10:51:55	198.2	138.1	15.4	46057.0	28455.0	74512.0	30	38	636	-	55	51
08/28/80	10:52:08	200.7	136.9	15.5	47845.0	28334.0	76179.0	29	37	636	-	56	52
08/28/80	10:52:46	203.2	147.3	15.5	48387.0	30012.0	78399.0	30	38	675	-	54	50
08/28/80	10:53:12	194.4	134.1	15.4	48477.0	31596.0	80073.0	32	39	676	-	53	49
08/28/80	10:53:18	194.4	135.3	15.4	49841.0	31138.0	80979.0	30	38	676	-	54	50
08/28/80	10:53:37	195.7	136.9	15.5	50757.0	30969.0	81727.0	30	38	676	-	54	50

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 6 of 11

HELICAL SCREW EXPANDER
3RD PERFORMANCE TEST DATA
ATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-------)	(--------klbm/h	-----------	-----------)	(--%--	--)	(kW)	(-----%	-----	---)
02/02/81	13:13:39	230.0	103.1	14.9	64.6	12.9	77.5	18	27	268	52	42	36
02/02/81	13:14:39	227.0	105.1	15.0	66.1	13.0	79.1	17	27	267	50	41	36
02/02/81	13:16:30	237.0	106.9	14.9	63.9	12.7	76.6	17	27	257	48	42	36
02/02/81	13:19:20	234.0	101.6	14.9	64.8	12.9	77.7	17	27	258	53	43	37
02/02/81	13:21:17	198.0	99.8	14.8	72.3	15.4	87.7	18	27	372	73	49	44
02/02/81	13:21:26	217.0	96.9	14.9	70.9	15.7	86.6	19	28	372	74	49	44
02/02/81	13:21:35	208.0	95.8	15.0	72.2	15.6	87.7	19	28	372	76	50	44
02/02/81	13:21:44	199.0	102.1	15.0	72.5	16.3	88.8	19	28	373	70	47	42
02/02/81	13:27:57	182.0	106.6	15.1	73.9	17.2	91.0	20	29	417	73	48	43
02/02/81	13:32:13	179.0	104.6	15.2	73.9	17.2	91.1	20	29	420	73	49	44
02/02/81	13:35:38	181.0	101.6	13.1	74.4	17.6	92.0	20	29	419	76	48	43
02/02/81	13:38:21	188.0	103.6	15.1	73.3	16.7	90.0	20	29	418	75	50	45
02/02/81	13:39:40	180.0	100.6	15.0	74.5	17.0	91.5	20	29	418	75	50	45
02/02/81	13:41:01	178.0	106.3	15.0	73.4	17.3	90.6	20	29	419	71	48	43
02/02/81	13:43:07	176.0	109.4	13.1	71.0	15.5	86.5	19	29	419	63	48	4
02/03/81	13:30:34	208.0	101.3	14.9	74.9	17.5	92.4	20	29	416	74	48	43
02/03/81	13:34:39	191.0	103.1	15.0	74.7	17.4	92.1	20	29	415	74	48	43
02/03/81	13:37:15	193.0	106.3	15.1	74.7	17.7	92.4	20	29	416	70	47	42
02/03/81	13:40:29	193.0	99.8	14.9	75.6	17.3	92.9	20	29	415	75	48	43
02/04/81	13:41:19	252.0	92.5	15.0	61.2	14.1	75.3	20	28	263	60	42	36
02/04/81	13:44:10	249.0	97.6	14.6	60.1	13.7	73.8	19	28	265	52	42	36
02/04/81	13:45:13	246.0	97.3	14.9	58.4	13.5	71.9	19	28	262	51	43	37
02/04/81	13:45:58	247.0	96.1	14.9	59.1	13.5	72.7	20	28	261	52	43	37
02/04/81	13:55:18	237.0	92.5	14.8	64.0	15.1	79.1	20	29	274	64	41	35

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 7 of 11

H E L I C A L   S C R E W   E X P A N D E R
3RD P E R F O R M A N C E   T E S T   D A T A
ATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(-------psia-------)			(---------klbm/h-----------)			(--%-)		(kW)	(----%---)		
02/04/81	13:56:12	222.0	97.6	14.9	62.7	15.1	77.8	20	29	273	55	40	35
02/04/81	13:56:30	222.0	96.8	14.9	61.4	14.9	76.2	20	29	273	55	41	35
02/04/81	13:56:48	229.0	92.8	14.9	64.1	15.5	79.6	21	29	274	62	40	35
02/05/81	10:53:02	224.0	94.6	14.7	75.8	13.0	88.8	16	25	268	65	42	36
02/05/81	10:53:38	212.0	101.6	14.7	74.4	12.5	87.0	15	25	268	56	42	36
02/05/81	10:54:23	213.0	101.8	15.1	74.0	12.7	86.7	15	25	268	56	42	36
02/05/81	10:55:08	218.0	99.6	14.8	72.3	12.2	84.5	15	25	268	56	44	37
02/05/81	10:59:15	236.0	105.1	14.9	65.6	12.7	78.4	17	26	268	52	42	36
02/05/81	11:01:12	241.0	103.1	15.2	63.5	13.2	76.6	18	27	268	51	43	37
02/05/81	14:22:20	273.0	162.1	15.4	92.6	27.2	119.8	24	34	871	73	50	47
02/05/81	14:22:47	281.0	161.1	15.8	92.6	27.0	119.6	24	34	871	72	51	48
02/05/81	14:23:50	272.0	171.0	15.7	92.5	26.5	119.0	23	34	871	66	50	47
02/05/81	14:24:35	256.0	168.7	15.7	92.5	26.3	118.8	23	34	870	67	51	48
02/05/81	14:24:53	262.0	173.2	15.7	92.5	26.4	118.9	23	34	881	67	51	48
02/05/81	14:25:02	271.0	169.5	15.7	92.5	26.5	119.0	23	34	880	68	51	48
02/05/81	14:25:20	257.0	172.7	15.8	92.5	26.3	118.8	23	34	880	67	51	48
02/05/81	14:25:47	267.0	166.7	15.6	92.5	27.0	119.5	24	34	882	68	50	47
02/05/81	14:26:05	254.0	174.0	15.7	92.5	27.5	119.9	24	35	881	63	49	46
02/05/81	14:28:11	249.0	171.4	15.8	92.4	27.7	120.1	24	35	915	72	51	48
02/05/81	14:30:19	257.0	163.9	15.6	92.4	27.2	119.6	24	35	914	75	52	49
02/05/81	14:32:25	230.0	160.9	16.0	92.5	28.6	121.1	25	35	915	77	51	48
02/05/81	14:34:04	236.0	168.9	16.2	92.5	28.1	120.6	24	35	916	71	51	48
02/05/81	14:36:32	239.0	170.7	15.8	92.4	27.1	119.5	24	35	896	67	51	46
02/05/81	14:38:38	245.0	170.9	15.7	92.4	27.2	119.6	24	35	897	65	50	47
02/05/81	14:39:41	238.0	170.9	15.6	92.4	27.8	120.2	24	35	893	66	49	46
02/05/81	14:41:20	240.0	172.4	15.7	90.9	28.2	119.1	25	36	895	66	49	46
02/05/81	14:42:45	239.0	168.6	16.1	90.4	27.7	118.1	25	35	895	67	50	47

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 8 of 11

HELICAL SCREW EXPANDER
3RD PERFORMANCE TEST DATA
ATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-)	(--------klbm/h	----------	-)	(--%-)		(kW)	(----%	---	-)
02/05/81	14:44:15	239.0	169.1	16.0	90.7	28.0	118.6	25	35	895	67	50	47
02/05/81	14:44:42	237.0	169.7	15.4	90.8	27.6	118.4	25	35	896	67	50	47
02/05/81	14:45:36	240.0	168.7	15.6	91.4	27.8	119.2	25	35	896	66	50	47
02/05/81	14:47:06	244.0	168.5	15.7	91.9	28.7	120.6	25	36	929	70	50	47
02/05/81	14:48:36	242.0	170.7	15.8	89.5	29.4	118.9	26	36	929	69	50	47
02/05/81	14:49:37	239.0	166.9	15.8	85.7	28.9	114.6	27	37	928	69	51	48
02/05/81	14:50:01	240.0	165.9	15.8	86.0	29.2	115.2	27	37	928	70	51	48
02/05/81	14:51:59	238.0	165.7	15.4	90.3	29.6	119.9	26	36	933	71	49	47
02/05/81	14:52:53	244.0	169.4	15.6	89.2	28.6	117.8	26	36	915	69	50	47
02/05/81	14:59:28	248.0	167.6	15.3	90.1	28.9	119.0	26	36	924	69	49	46
02/05/81	15:01:20	251.0	169.6	16.1	90.4	28.6	119.0	25	36	915	68	50	47
02/05/81	15:02:00	250.0	167.9	15.5	90.3	28.4	118.7	25	36	924	67	50	47
02/05/81	15:03:47	242.0	169.2	16.1	91.7	29.0	120.7	25	36	933	69	51	48
02/05/81	15:04:23	243.0	170.4	15.7	91.9	29.1	121.0	25	36	934	68	50	47
02/05/81	15:05:35	237.0	176.0	16.2	91.9	29.7	121.5	25	37	934	64	49	46
02/05/81	15:10:28	257.0	185.8	15.6	81.4	24.8	106.2	24	35	786	47	48	45
02/05/81	15:10:37	272.0	180.5	15.7	82.7	25.0	107.7	24	35	787	48	48	45
02/05/81	15:10:55	254.0	183.8	15.6	82.4	24.6	107.0	23	35	783	48	48	45
02/05/81	15:11:17	306.0	166.2	15.6	82.6	24.4	107.0	24	35	785	58	50	47
02/06/81	14:35:37	209.0	141.0	15.0	68.7	13.5	82.2	15	27	267	32	36	31
02/06/81	14:35:52	229.0	135.8	15.1	67.8	13.0	80.8	15	27	265	33	37	32
02/06/81	14:36:07	236.0	138.0	15.1	67.3	12.3	79.5	14	26	265	33	39	33
02/06/81	14:36:22	215.0	141.0	15.3	69.3	13.9	83.3	15	27	313	34	40	35
02/06/81	14:36:37	203.0	145.1	14.8	71.6	13.6	85.1	14	26	313	35	40	35
02/06/81	14:37:37	194.0	131.2	14.8	85.8	17.8	103.6	17	28	466	56	45	41
02/06/81	14:37:52	212.0	132.0	15.2	84.3	18.1	102.3	17	28	465	52	45	41
02/06/81	14:38:07	213.0	130.5	14.7	83.6	18.0	101.5	18	28	468	55	45	41

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 9 of 11

H E L I C A L   S C R E W   E X P A N D E R
3RD P E R F O R M A N C E   T E S T   D A T A
ATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	)	(--------klbm/h	----------	)	(--%-)		(kW)	(----%	---	)
02/06/81	14:39:37	204.0	143.8	15.7	82.4	18.5	100.9	18	29	501	47	46	42
02/06/81	14:40:07	204.0	145.0	15.6	81.3	18.3	99.6	18	29	501	48	46	42
02/06/81	14:41:07	214.0	136.3	14.6	80.3	17.9	98.2	19	30	501	51	46	42
02/06/81	14:41:37	217.0	140.3	15.3	80.2	17.6	97.8	18	29	501	52	47	43
02/06/81	14:43:32	208.0	141.8	14.7	79.4	17.7	97.2	19	30	511	50	46	42
02/06/81	14:45:07	213.0	137.3	14.5	79.8	18.3	98.1	20	30	511	51	45	41
02/06/81	14:45:52	213.0	143.0	15.5	78.9	18.2	97.1	19	30	510	48	46	42
02/06/81	14:48:14	226.0	137.5	14.7	78.2	18.1	96.3	20	30	511	52	46	42
02/06/81	14:49:29	241.0	145.3	14.5	76.8	17.2	94.0	19	30	511	48	47	43
02/06/81	14:52:14	245.0	181.8	14.6	74.2	17.9	92.0	18	31	512	33	43	39
02/06/81	14:53:29	247.0	179.7	14.7	73.3	17.6	90.9	19	32	511	33	43	39
02/06/81	14:54:46	261.0	173.0	15.5	72.1	17.4	89.5	20	32	511	34	44	40
02/06/81	14:56:04	253.0	179.4	15.2	72.8	17.3	90.2	19	32	511	33	43	39
02/06/81	14:57:30	265.0	176.0	15.5	74.1	17.4	91.4	19	32	511	34	43	40
02/06/81	14:59:36	293.0	173.4	14.8	71.7	16.3	88.0	19	31	511	36	45	41

Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 10 of 11

H E L I C A L   S C R E W   E X P A N D E R
3RD   P E R F O R M A N C E   T E S T   D A T A
ATMOSPHERIC EXHAUST PRESSURE

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-------)	(--------klbm/h	----------	----------)	(--%-	-)	(kW)	(----	-%-	---)
02/20/81	09:51:40	164.0	97.9	15.1	57.5	12.9	70.4	19	28	265	49	45	39
02/20/81	09:52:10	166.0	98.4	15.0	57.6	13.1	70.7	19	28	267	47	44	38
02/20/81	09:53:10	-162.0	99.2	14.3	56.2	12.9	69.1	19	29	265	46	43	37
02/20/81	09:54:10	163.0	101.5	14.8	55.7	12.5	68.1	19	28	266	46	45	39
02/20/81	09:59:40	166.0	97.2	14.3	56.2	13.2	69.4	20	29	270	50	44	38
02/20/81	10:00:40	164.0	98.9	15.1	54.8	13.0	67.7	20	29	270	49	46	40
02/20/81	10:01:25	158.0	97.7	15.0	56.4	13.3	69.7	20	29	270	50	45	39
02/20/81	10:02:40	157.0	101.2	14.1	55.1	12.7	67.8	19	29	271	46	44	38
02/20/81	10:00:55	155.0	98.0	15.3	52.3	13.8	66.1	22	30	271	45	45	39
02/20/81	10:12:18	157.0	99.0	14.6	53.8	13.4	67.1	21	29	271	48	44	38
02/20/81	10:14:54	154.0	98.2	14.9	53.5	13.7	67.2	21	30	272	48	44	38
02/20/81	10:17:58	154.0	100.0	14.1	54.6	13.0	67.6	20	29	273	47	44	38
02/20/81	10:18:13	160.0	98.5	14.1	53.4	12.9	66.2	20	29	271	48	45	39
02/20/81	10:20:28	154.0	100.5	15.5	55.4	13.2	68.7	20	29	271	46	45	39
02/20/81	10:22:13	164.0	99.0	13.7	53.1	12.6	65.6	20	29	271	47	45	39
02/20/81	12:57:12	233.0	167.5	13.2	92.6	25.8	118.4	23	34	834	68	46	43
02/20/81	13:16:08	239.0	171.5	15.2	87.6	28.1	115.7	26	36	892	75	49	46
02/20/81	13:16:21	237.0	174.3	15.6	88.3	29.0	117.3	26	37	892	72	48	45
02/20/81	13:18:33	238.0	174.0	16.2	87.9	28.6	116.5	26	36	892	71	49	46
02/20/81	13:19:00	236.0	172.8	15.9	89.7	28.9	118.6	26	36	893	73	48	45
02/20/81	13:19:09	238.0	175.3	16.0	86.2	27.5	113.7	25	36	854	63	48	45
02/20/81	13:19:27	240.0	179.8	15.8	84.8	27.6	112.4	26	36	835	57	48	45
02/20/81	13:19:45	245.0	180.1	15.8	84.6	27.6	112.2	26	36	855	59	48	45
02/20/81	13:19:54	244.0	178.8	15.6	85.0	27.5	112.5	25	36	854	61	48	45
02/20/81	13:25:28	208.0	174.8	15.1	65.2	18.1	83.3	22	34	511	29	43	39
02/20/81	13:25:52	201.0	176.8	14.6	65.8	18.0	83.7	22	34	511	30	42	39
02/20/81	13:27:14	201.0	173.8	15.0	66.2	17.4	83.6	21	33	510	30	44	40
02/20/81	13:28:24	200.0	176.6	14.5	68.5	17.2	85.7	21	33	511	30	43	40
02/20/81	13:30:51	200.0	172.3	14.7	71.4	17.3	88.7	20	32	511	32	43	40
02/20/81	13:34:31	200.0	164.2	14.8	73.6	17.0	90.6	20	31	512	36	44	41

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Table A-6. Atmospheric Exhaust Pressure Test Data, 2nd and 3rd Performance Test, 3000 rpm and 4000 rpm, Part 11 of 11

HELICAL SCREW EXPANDER
3RD PERFORMANCE TEST DATA
ATMOSPHERIC EXHAUST PRESSURE

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------	psia	-------)	(--------	klbm/h	----------)	(--	%-)	(kW)	(----	%	---)
02/20/81	13:46:37	169.0	138.4	14.8	73.6	18.0	91.5	21	31	514	47	47	43
02/20/81	13:47:53	169.0	139.4	14.9	74.9	18.9	93.7	21	32	516	48	45	42
02/20/81	13:50:24	171.0	138.1	14.8	73.2	18.4	91.6	21	31	516	48	46	43
02/20/81	13:51:04	172.0	138.6	14.6	74.0	18.3	92.4	21	31	515	48	46	42
02/20/81	13:52:43	198.0	138.4	15.4	86.5	22.5	109.1	22	32	649	75	48	45
02/20/81	13:52:52	198.0	140.6	14.9	86.6	22.0	108.6	21	31	650	69	48	45
02/20/81	13:53:01	199.0	139.6	14.8	87.3	22.3	109.5	21	32	650	73	48	44
02/20/81	13:55:29	199.0	139.9	15.3	85.2	22.7	107.9	22	32	667	73	49	46
02/20/81	13:57:27	205.0	137.8	15.4	85.7	23.3	109.0	23	33	665	75	48	45
02/20/81	13:59:49	203.0	141.1	15.2	82.9	22.5	105.4	23	33	664	71	49	46
02/20/81	14:01:42	206.0	138.6	15.1	84.7	22.7	107.4	22	32	666	75	49	45
02/20/81	14:15:26	205.0	140.9	14.8	56.4	11.7	68.0	18	29	276	25	40	34
02/20/81	14:18:24	194.0	145.9	14.8	56.3	12.1	68.4	18	29	277	23	38	33
02/20/81	14:19:43	210.0	142.4	14.8	54.8	11.4	66.2	17	29	277	24	41	35
02/20/81	14:21:44	215.0	139.6	14.6	54.7	11.9	66.7	18	30	276	26	39	34
02/20/81	14:30:26	175.0	103.2	14.4	61.4	12.8	74.2	18	28	278	46	43	38
02/20/81	14:32:15	170.0	105.1	14.6	59.2	12.5	71.8	18	28	281	44	45	39
02/20/81	14:33:20	177.0	102.4	14.7	58.2	12.8	71.0	19	28	281	47	45	39
02/20/81	14:34:43	160.0	106.4	15.0	59.3	13.1	72.4	19	28	281	43	44	38
02/20/81	14:43:46	161.0	106.4	14.8	56.7	12.9	69.6	19	28	280	45	45	39
02/20/81	14:46:14	157.0	104.9	14.5	55.3	12.9	68.2	19	29	281	44	45	39
02/20/81	14:59:27	163.0	103.1	15.0	58.4	16.6	75.0	23	31	377	64	48	43
02/20/81	15:01:14	164.0	101.9	14.7	58.5	16.7	75.2	23	31	377	64	48	43
02/20/81	15:02:51	163.0	102.6	14.7	59.5	16.4	75.9	22	31	377	65	49	43
02/20/81	15:03:06	168.0	102.4	14.8	59.3	16.6	75.9	23	31	377	64	48	42

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Table A-7. Above-Atmospheric Exhaust Pressure Test Data, 3000 rpm and 4000 rpm (Ref. A, Appendix E), Part 1 of 2

HELICAL SCREW EXPANDER
2ND PERFORMANCE TEST DATA
ABOVE-ATMOSPHERIC EXHAUST PRESSURE

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-------)	(----------	lbm/h	----------)	(--%	-)	(kW)	(----	%	---)
08/18/80	12:51:05	161.7	97.9	25.9	37321.0	19220.0	56542.0	28	34	222	74	49	42
08/18/80	12:51:55	167.4	99.4	24.4	38565.0	20025.0	58590.0	28	34	222	72	45	38
08/18/80	12:52:55	164.2	97.6	24.8	37569.0	19923.0	57491.0	29	35	220	70	46	39
08/18/80	12:53:49	171.1	98.8	24.9	37321.0	19201.0	56522.0	28	34	220	71	48	40
08/18/80	12:55:24	170.5	102.2	24.8	37486.0	18483.0	55969.0	27	33	220	69	48	41
08/18/80	12:56:21	170.5	98.2	24.8	37239.0	19214.0	56453.0	28	34	219	69	47	40
08/18/80	12:58:15	171.1	97.6	24.0	36011.0	17785.0	53796.0	27	33	219	70	51	43
08/18/80	13:15:39	224.6	142.3	32.0	43159.0	29207.0	72366.0	35	40	383	-	45	40
08/18/80	13:18:03	235.3	136.7	32.0	42553.0	28577.0	71130.0	35	40	385	68	47	42
08/18/80	13:20:24	240.3	139.8	31.6	42813.0	27740.0	70553.0	34	39	383	68	47	43
08/18/80	13:22:06	241.6	146.0	31.7	41009.0	26947.0	67956.0	34	40	383	59	48	43
08/18/80	13:22:31	242.8	144.4	30.8	41436.0	28472.0	69909.0	35	41	384	61	45	40
08/18/80	13:23:43	249.1	132.7	32.3	44205.0	29499.0	73704.0	35	40	384	85	47	42
08/18/80	13:37:31	247.9	176.2	39.9	56000.0	36128.0	92128.0	33	39	472	64	43	39
08/18/80	13:39:19	246.6	176.2	40.2	55050.0	35679.0	90729.0	33	39	471	62	44	40
08/18/80	13:40:49	248.5	177.1	39.6	54861.0	35560.0	90421.0	33	39	471	63	43	40
08/18/80	13:42:19	254.2	172.8	40.5	56000.0	35050.0	91050.0	32	38	471	-	45	41
08/18/80	13:48:34	258.6	172.2	39.5	56381.0	35416.0	91797.0	32	39	471	69	44	40
08/18/80	13:49:28	259.8	173.7	41.3	55714.0	34611.0	90325.0	32	38	472	63	46	42
08/18/80	13:50:08	259.8	168.8	40.1	56477.0	36432.0	92909.0	33	39	470	73	44	40
08/18/80	13:51:34	259.2	179.2	39.8	56286.0	35821.0	92107.0	32	39	465	59	42	39

Table A-7. Above-Atmospheric Exhaust Pressure Test Data, 3000 rpm and 4000 rpm
Part 2 of 2

HELICAL SCREW EXPANDER
2ND PERFORMANCE TEST DATA
ABOVE-ATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia-------		)	(----------lbm/h----------)			(--%-)		(kW)	(----%---)		
08/27/80	10:15:52	186.9	93.4	24.4	43159.0	22268.0	65428.0	28	34	211	-	42	35
08/27/80	10:16:07	183.1	100.5	25.3	42726.0	22763.0	65489.0	29	35	212	-	39	33
08/27/80	10:16:39	181.2	93.7	25.2	43159.0	23159.0	66319.0	29	35	251	-	40	34
08/27/80	10:17:05	183.7	98.3	25.0	42813.0	22515.0	65328.0	28	34	211	-	40	33
08/27/80	10:18:20	186.2	100.5	24.9	42986.0	23271.0	66257.0	29	35	211	-	38	32
08/27/80	10:18:45	179.9	95.8	24.8	42813.0	22682.0	65495.0	29	35	213	-	40	34
08/27/80	10:19:04	184.3	98.0	24.5	42640.0	21935.0	64575.0	28	34	211	-	41	34
08/27/80	10:19:56	180.6	97.7	25.1	43420.0	23241.0	66662.0	29	35	212	-	39	33
08/27/80	10:20:15	179.3	103.9	23.8	43768.0	22628.0	66397.0	27	34	211	-	38	31
08/27/80	10:20:53	179.3	101.4	24.6	44468.0	23212.0	67680.0	28	34	211	-	38	31
08/27/80	10:43:06	194.4	140.2	32.9	53355.0	29230.0	82585.0	29	35	287	-	37	32
08/27/80	10:43:12	190.6	141.5	32.2	55050.0	29578.0	84628.0	28	35	288	-	36	31
08/27/80	10:43:21	195.0	146.1	32.0	54861.0	28994.0	83854.0	27	35	289	-	36	31
08/27/80	10:43:27	193.8	143.6	32.2	55524.0	30377.0	85901.0	28	35	288	-	35	30
08/27/80	10:43:34	191.9	141.8	32.3	54766.0	29508.0	84274.0	28	35	287	-	36	31
08/27/80	10:43:40	193.8	143.3	32.4	54955.0	30082.0	85037.0	28	35	287	-	35	30
08/27/80	10:43:47	196.9	143.0	31.8	56000.0	29600.0	85599.0	27	35	288	-	35	31
08/27/80	10:43:53	192.5	144.8	32.1	55714.0	29285.0	84999.0	27	34	288	-	36	31
08/27/80	10:45:03	194.4	144.6	32.8	56095.0	29280.0	85375.0	27	34	288	-	36	31
08/27/80	10:45:10	196.9	144.2	32.5	53636.0	29446.0	83083.0	28	35	288	-	36	31
08/27/80	11:22:27	220.2	175.7	40.4	65712.0	37617.0	103329.0	29	36	399	-	36	33
08/27/80	11:22:41	218.3	176.0	38.9	59759.0	37160.0	96919.0	31	38	399	-	36	32
08/27/80	11:22:57	217.7	175.7	39.4	63805.0	37624.0	101429.0	30	37	399	-	36	32
08/27/80	11:23:27	219.6	174.4	40.1	62512.0	37787.0	10029[illegible].0	31	38	401	-	36	33
08/27/80	11:24:41	217.0	177.5	39.8	61622.0	37995.0	99617.0	31	38	399	-	36	32
08/27/80	11:25:11	219.6	180.0	39.9	60541.0	37579.0	98119.0	31	38	399	-	36	32
08/27/80	11:25:58	217.0	173.8	39.8	59369.0	37755.0	97125.0	32	39	400	-	36	32
08/27/80	11:27:14	219.6	177.8	38.9	61031.0	37399.0	98430.0	31	38	399	-	36	32
08/27/80	11:27:23	219.6	177.2	40.7	59369.0	38554.0	97924.0	33	39	399	-	35	32
08/27/80	11:27:32	217.7	178.4	39.3	59369.0	36974.0	96343.0	31	38	399	-	36	32

Table A-8. Above-Atmospheric Exhaust Pressure Test Data, Average Values (Ref. A, Table 7)

Line	Date	Pp	Pe	Po	Wa	Wv	Wt	Xe	KW	Rm	Speed
		(-	- psia -	-)	(-	- lbm/h -	-)	(%)	(kW)	(%)	(rpm)
1	08/18/80	168	99	25	37359	19121	56480	28	220	47.7	3000
2	08/18/80	240	140	32	42529	28407	70936	35	384	46.5	3000
3	08/18/80	255	175	40	55846	35587	91433	33	470	43.8	3000
4	08/27/80	183	98	24	43196	22764	65963	28	211	39.5	4000
5	08/27/80	194	143	32	54996	29538	84534	28	288	35.6	4000
6	08/27/80	219	177	40	61309	37644	98953	31	399	35.9	4000

Table A-9. Subatmospheric Exhaust Pressure Test Data (Ref. A, Appendix F), Part 1 of 4

H E L I C A L   S C R E W   E X P A N D E R
3RD   P E R F O R M A N C E   T E S T   D A T A
SUBATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	-)	(--------klbm/h	----------	-)	(--%-)		(kW)	(----%	---	-)
02/03/81	14:12:59	240.0	113.6	5.6	60.5	11.2	71.6	16	29	399	40	42	38
02/03/81	14:14:14	201.0	116.7	5.7	62.9	12.4	75.3	17	30	416	41	40	36
02/03/81	14:15:44	199.0	115.9	5.7	64.6	13.0	77.5	17	30	417	41	38	35
02/03/81	14:16:29	198.0	112.6	5.7	65.5	13.0	78.4	17	30	416	42	39	35
02/03/81	14:17:29	217.0	112.6	5.7	63.7	12.6	76.3	17	30	416	44	40	36
02/03/81	14:18:44	202.0	113.2	5.5	66.6	13.6	80.2	17	31	416	42	37	33
02/03/81	14:19:44	211.0	112.9	5.7	63.7	12.1	75.8	17	30	416	41	41	37
02/03/81	14:22:12	206.0	114.4	5.7	64.4	12.2	76.7	17	30	416	45	40	36
02/03/81	14:24:33	218.0	110.1	5.5	65.1	12.8	77.9	17	30	416	43	39	35
02/03/81	14:25:03	195.0	114.9	5.2	65.0	12.7	77.7	17	31	417	40	38	34
02/03/81	14:25:28	198.0	113.7	5.1	64.2	12.2	76.4	17	30	416	40	39	35
02/03/81	14:25:43	217.0	112.6	5.0	62.5	11.5	74.0	16	30	416	42	41	37
02/03/81	14:26:28	219.0	11[illegible].9	5.5	64.4	12.3	76.8	17	30	416	41	39	36
02/03/81	14:26:43	193.0	116.1	5.8	66.2	13.2	79.4	17	30	416	41	38	34
02/05/81	11:52:38	226.0	101.1	6.5	53.3	11.5	64.8	18	30	268	33	33	29
02/05/81	11:53:00	223.0	102.9	6.5	53.9	11.3	65.3	18	30	269	33	34	29
02/05/81	11:53:18	226.0	101.8	6.6	52.4	10.5	62.9	17	29	268	36	36	31
02/05/81	11:54:03	226.0	99.4	6.5	53.3	11.6	64.9	18	30	268	34	34	29
02/05/81	11:54:48	222.0	105.6	6.6	54.1	10.7	64.7	17	29	268	31	35	30
02/05/81	11:56:32	227.0	103.1	6.6	51.4	10.6	62.0	17	30	268	36	36	31
02/05/81	11:57:57	224.0	102.9	6.8	52.3	11.3	63.6	18	30	268	36	34	30
02/05/81	11:59:11	217.0	104.9	6.8	50.1	10.5	60.6	18	30	271	33	37	32
02/05/81	11:59:47	221.0	102.6	6.9	52.4	11.7	64.1	19	31	271	34	34	29
02/05/81	12:02:01	220.0	108.4	6.7	52.2	10.7	62.9	17	29	271	32	36	31
02/05/81	12:02:36	227.0	98.8	6.8	51.9	11.4	63.3	19	30	270	37	35	30
02/05/81	12:03:16	237.0	99.1	6.5	50.7	10.8	61.4	18	30	271	38	36	31
02/05/81	12:07:50	227.0	143.3	5.7	53.2	9.4	62.6	15	30	271	19	32	27

Table A-9. Subatmospheric Exhaust Pressure Test Data, Part 2 of 4

HELICAL SCREW EXPANDER
3RD PERFORMANCE TEST DATA
SUBATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------psia	-------	)	(--------klbm/h	----------	)	(--%-)		(kW)	(----%-	--	)
02/05/81	13:03:12	241.0	140.3	5.8	50.4	9.2	59.6	16	31	266	20	32	28
02/05/81	13:03:55	240.0	142.8	5.7	52.5	10.2	62.7	16	32	266	18	30	25
02/05/81	13:04:21	240.0	142.3	5.8	49.7	8.5	58.3	15	30	268	20	34	29
02/05/81	13:04:56	215.0	146.3	5.7	53.1	10.1	63.2	16	31	267	18	30	25
02/05/81	13:05:32	223.0	142.8	5.7	55.2	10.1	65.3	16	31	264	16	29	25
02/05/81	13:38:01	222.0	138.0	6.4	70.6	15.5	86.1	18	32	534	40	40	36
02/05/81	13:40:13	238.0	133.0	6.5	70.1	15.5	85.6	19	32	532	43	40	37
02/05/81	13:41:09	248.0	130.5	6.4	69.7	16.1	85.8	20	33	533	41	39	36
02/05/81	13:42:21	222.0	140.0	6.5	71.3	15.9	87.2	19	32	534	39	39	36
02/05/81	13:42:57	225.0	135.5	6.5	70.0	15.3	85.4	19	32	533	42	40	37
02/05/81	14:12:57	215.0	137.8	12.5	82.9	24.2	107.1	24	34	755	74	48	45
02/05/81	14:14:46	211.0	137.0	13.4	85.5	25.0	110.5	24	34	754	76	48	45
02/05/81	14:15:26	211.0	135.7	12.8	85.2	24.6	109.8	24	34	753	76	48	45
02/05/81	14:15:44	221.0	135.2	13.0	84.7	24.4	109.1	24	34	755	80	49	46
02/05/81	14:16:20	214.0	132.5	12.8	83.6	24.3	107.9	24	34	755	80	49	46
02/05/81	14:16:47	216.0	145.3	12.8	84.5	24.6	109.0	23	34	754	67	47	44
02/05/81	14:17:32	276.0	139.3	12.6	83.1	24.5	107.5	24	34	752	71	48	45
02/06/81	10:39:02	220.0	105.6	4.1	55.8	6.9	62.7	11	26	266	23	38	33
02/06/81	10:41:37	219.0	106.9	4.1	64.6	7.2	71.8	10	26	265	29	34	30
02/06/81	10:42:20	222.0	99.8	4.1	64.3	8.2	72.5	12	27	265	31	33	28
02/06/81	10:45:33	216.0	104.3	4.0	63.3	8.3	71.6	12	27	266	29	32	28
02/06/81	10:47:14	228.0	107.3	4.1	60.1	7.1	67.2	11	26	265	29	36	31
02/06/81	10:52:28	220.0	107.6	4.1	61.5	8.1	69.6	12	27	265	29	33	28
02/06/81	11:13:29	182.0	65.9	5.4	51.3	11.0	62.3	18	29	273	66	42	36
02/06/81	11:13:56	184.0	65.4	5.5	50.9	11.0	61.8	19	29	273	69	42	37
02/06/81	11:14:38	200.0	63.4	5.5	48.0	10.2	58.3	19	28	272	71	46	39
02/06/81	11:15:20	179.0	68.9	5.4	50.8	11.3	62.0	19	29	273	62	40	35

Table A-9. Subatmospheric Exhaust Pressure Test Data, Part 3 of 4

H E L I C A L   S C R E W   E X P A N D E R
3RD   P E R F O R M A N C E   T E S T   D A T A
SUBATMOSPHERIC EXHAUST PRESSURE

4000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Xe	Xo	KW	Thr	Rm	Rt
		(------	psia-------	-)	(--------	klbm/h------	-----)	(--%	-)	(kW)	(----	%---	-)
02/06/81	15:35:16	223.0	137.0	6.3	67.9	14.4	82.3	18	32	516	39	41	37
02/06/81	15:36:07	205.0	141.5	6.4	68.7	14.8	83.5	18	32	516	37	40	36
02/06/81	15:39:56	229.0	141.2	6.4	68.2	14.2	82.4	18	32	517	38	41	37
02/06/81	15:41:26	216.0	144.5	6.4	68.9	13.9	82.8	17	31	517	36	41	38
02/06/81	15:41:57	217.0	139.8	6.4	69.4	15.2	84.5	19	32	516	36	39	35
02/07/81	11:49:24	235.0	110.7	3.2	46.7	8.8	55.5	16	31	271	23	33	28
02/07/81	11:51:12	223.0	114.2	3.1	46.7	8.5	55.3	15	31	271	22	33	28
02/07/81	11:55:14	222.0	111.7	3.2	47.8	8.4	56.2	15	31	271	23	33	28
02/07/81	11:56:08	242.0	110.5	3.2	46.0	8.0	54.0	15	30	271	23	35	30
02/07/81	12:00:57	225.0	103.9	4.2	56.2	11.7	69.9	17	31	377	41	37	33
02/07/81	12:04:14	244.0	100.1	4.2	54.1	10.9	65.0	18	31	374	40	40	36
02/07/81	12:04:59	241.0	101.9	4.2	54.6	11.3	65.9	18	31	373	40	39	34
02/07/81	12:07:42	229.0	105.6	4.2	55.2	11.5	66.7	18	31	376	38	38	34
02/07/81	12:10:52	240.0	98.3	4.3	56.3	12.0	68.3	18	32	379	43	38	34
02/07/81	12:16:22	233.0	97.3	6.1	63.9	15.5	79.4	20	32	504	68	45	41
02/07/81	12:17:33	237.0	90.3	6.0	66.2	16.1	82.2	21	32	506	82	44	40
02/07/81	12:19:09	214.0	98.1	6.5	66.2	15.9	82.1	20	31	506	69	44	40
02/07/81	12:2[illegible]:32	222.0	93.0	6.4	69.7	16.4	86.1	20	31	507	74	43	40

Table A-9. Subatmospheric Exhaust Pressure Test Data, Part 4 of 4

HELICAL SCREW EXPANDER
3RD PERFORMANCE TEST DATA
SUBATMOSPHERIC EXHAUST PRESSURE

3000 rpm

DATE	TIME	Pp	Pe	Po	Wa	Wv	Wt	Vc	Xo	KW	Thr	Rm	Rt
		(------psia-------		)	(---------klbm/h-		-----------)	--%-)		(kW)	(----%---)		
02/20/81	10:54:28	187.0	101.7	4.0	45.1	9.4	54.5	18	31	272	26	35	30
02/20/81	11:01:06	184.0	104.0	3.8	45.1	9.7	54.8	18	32	271	24	33	29
02/20/81	11:04:18	188.0	103.5	3.7	44.2	8.9	53.1	17	31	273	25	35	31
02/20/81	11:11:18	167.0	97.5	4.3	54.9	12.1	67.0	19	32	382	44	38	34
02/20/81	11:13:18	168.0	96.9	4.5	54.7	12.2	66.9	19	32	383	45	39	35
02/20/81	11:14:03	155.0	98.8	4.3	56.9	13.4	70.3	20	33	383	42	35	32
02/20/81	11:17:54	157.0	*102.2	4.4	55.1	11.0	66.1	17	30	382	43	41	36
02/20/81	11:21:10	166.0	99.2	4.5	56.1	12.5	68.6	19	32	383	44	38	34
02/20/81	11:27:25	163.0	94.0	5.6	63.3	14.9	78.2	20	32	462	69	42	38
02/20/81	11:28:55	164.0	94.5	5.6	63.2	14.9	78.2	20	32	462	68	42	38
02/20/81	11:31:09	168.0	96.5	5.6	62.8	15.0	77.8	20	32	464	66	41	38
02/20/81	11:34:54	160.0	91.4	5.6	64.4	16.2	80.7	21	33	464	69	40	36
02/20/81	11:37:09	166.0	96.2	5.7	63.8	16.1	79.9	21	33	465	64	39	36
02/20/81	11:48:54	209.0	140.2	6.2	68.3	15.7	84.0	19	33	516	36	38	35
02/20/81	11:49:54	227.0	139.4	6.2	67.1	15.6	82.8	19	33	514	36	38	35
02/20/81	11:51:09	227.0	143.5	6.3	66.9	14.8	81.7	18	32	514	36	39	36
02/20/81	11:53:15	220.0	145.7	6.2	69.3	15.7	85.0	19	33	517	34	37	34
02/20/81	11:55:00	240.0	138.6	6.2	67.5	14.9	82.4	19	32	516	37	39	36
02/20/81	11:56:35	224.0	143.9	6.2	67.6	15.3	82.8	19	33	516	35	38	35
02/20/81	12:15:28	205.0	138.7	8.6	77.8	20.0	97.8	21	33	645	54	42	39
02/20/81	12:18:55	206.0	137.6	8.4	77.1	19.5	96.6	21	33	645	55	42	39
02/20/81	12:19:55	209.0	142.9	8.3	80.0	20.3	100.3	21	33	645	54	40	37
02/20/81	12:45:15	277.0	176.3	6.4	69.4	14.8	84.2	18	33	519	25	36	33
02/20/81	12:48:12	280.0	181.8	6.4	68.4	14.5	82.8	17	33	521	22	37	34
02/20/81	12:49:55	264.0	177.1	6.3	69.6	15.8	8[illegible].3	19	34	521	23	34	32
02/20/81	12:51:53	277.0	175.3	6.5	69.8	14.9	84.[illegible]	18	33	520	25	36	33
02/20/81	12:52:56	282.0	176.6	6.4	70.6	1[illegible].4	86.0	18	34	520	24	35	32

Table A-10. Subatmospheric Exhaust Pressure Test Data, Average Values (Ref. A, Table 8)

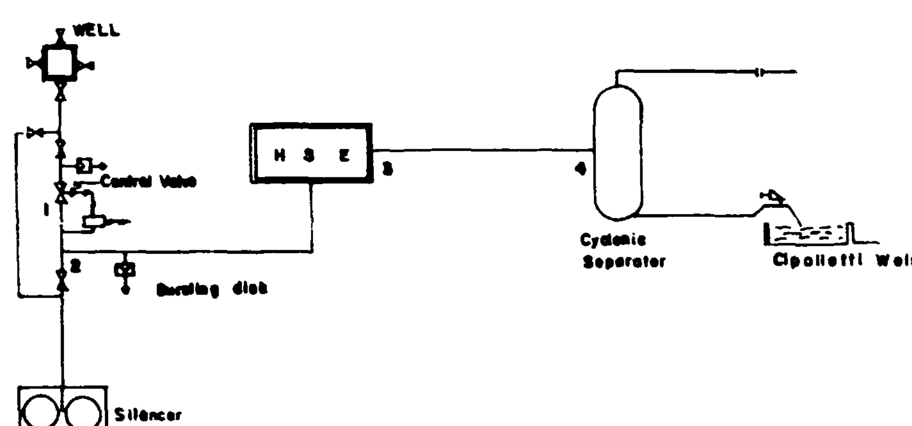
Line	Date	Pp	Pe	Po	Wa	Wv	Wt	Xe	KW	Rm	Speed
		(- - psia		- -)	(- -	klb/h -	-)	(%)	(kW)	(%)	(rpm)
1	02/20/81	186	103	3.8	45	9	54	18	272	34.3	3000
2	02/20/81	163	99	4.4	56	12	68	19	383	38.2	3000
3	02/20/81	164	95	5.6	64	15	79	20	463	40.8	3000
4	02/20/81	225	142	6.2	68	15	83	19	516	38.1	3000
5	02/20/81	207	140	8.4	78	20	98	21	645	41.3	3000
6	02/20/81	276	177	6.4	70	15	85	18	520	35.6	3000
7	02/07/81	231	112	3.1	47	8	55	15	271	33.5	4000
8	02/06/81	221	105	4.1	62	8	69	11	265	34.3	4000
9	02/07/81	235	103	4.2	56	11	67	18	375	38.5	4000
10	02/06/81	186	63	5.5	50	11	61	19	273	42.5	4000
11	02/03/81	208	114	5.5	64	12	76	17	415	39.4	4000
12	02/07/81	227	95	6.2	67	16	83	20	506	44.0	4000
13	02/05/81	225	103	6.6	52	11	63	18	270	35.0	4000
14	02/05/81	231	143	5.7	52	10	62	16	267	31.2	4000
15	02/05/81	218	141	6.4	69	15	84	18	516	40.4	4000
16	02/05/81	231	135	6.5	70	16	86	19	533	39.6	4000
17	02/05/81	222	137	12.8	84	24	108	24	754	48.1	4000

Table A-11. Comparison Between Atmospheric and Subatmospheric Exhaust Pressure Tests (Ref. A, Table 9)

Date	Time	Pp	Pe	Po	Wt	Xe	Speed	KW	Rm	Specific Flow rate
		(- -	psia -	-)	(klb/h)	(%)	(rpm)	(kW)	(%)	(lb/kWh)
02/02/81	13:13:39	230	103	14.88	77.53	17.5	4000	268	42.0	289.3
02/05/81	11:56:32	227	103	6.6	62.0	17.0	4000	268	36.0	231.3
02/02/81	13:43:07	176	109.4	13.06	86.5	18.7	4000	419	48.0	206.4
02/03/81	14:24:33	218	110.1	5.5	77.9	17.0	4000	416	39.0	187.3
02/02/81	13:21:44	199	102.1	14.98	88.81	19.1	4000	373	46.7	238.1
02/07/81	12:04:59	241	101.9	4.2	65.9	18.0	4000	373	39.0	176.7
02/06/81	14:36:07	236	138.0	15.1	79.54	14.0	4000	265	38.7	300.2
02/05/81	13:03:12	241	140.3	5.8	59.6	16.0	4000	266	32.0	224.1
02/06/81	14:43:32	208	141.8	14.69	97.17	18.9	4000	511	46.0	190.2
02/06/81	15:41:57	217	139.8	6.4	84.5	19.0	4000	516	39.0	163.8
02/20/81	10:02:40	157	101.2	14.1	67.8	19.0	3000	271	44.0	250.2
02/20/81	10:54:28	187	101.7	4.0	54.5	18.0	3000	272	35.0	200.4
02/20/81	13:51:04	172	138.6	14.6	92.4	21.0	3000	515	46.0	179.4
02/20/81	11:55:00	240	138.6	6.2	82.4	19.0	3000	516	39.0	159.7
02/20/81	13:53:01	199	139.6	14.8	109.5	21.0	3000	650	48.0	168.5
02/20/81	12:15:28	205	138.7	8.6	97.8	21.0	3000	645	42.0	151.6

Table A-12. Chemical Composition of Scale Samples (Ref. A, Table 10)

LOCATION	VALUES IN WEIGHT PERCENT						
	Na	Ca	Mg	Fe	K	S	SiO_2
1	0.227	0.660	0.046	0.810	0.386	0.36	98.276
2	0.245	0.200	0.020	0.614	0.130	2.20	97.062
3	0.253	0.203	0.051	0.373	0.130	0.20	99.065
4	0.223	0.172	0.031	1.435	0.136	0.39	89.433



APPENDIX B

ITALY/ENEL

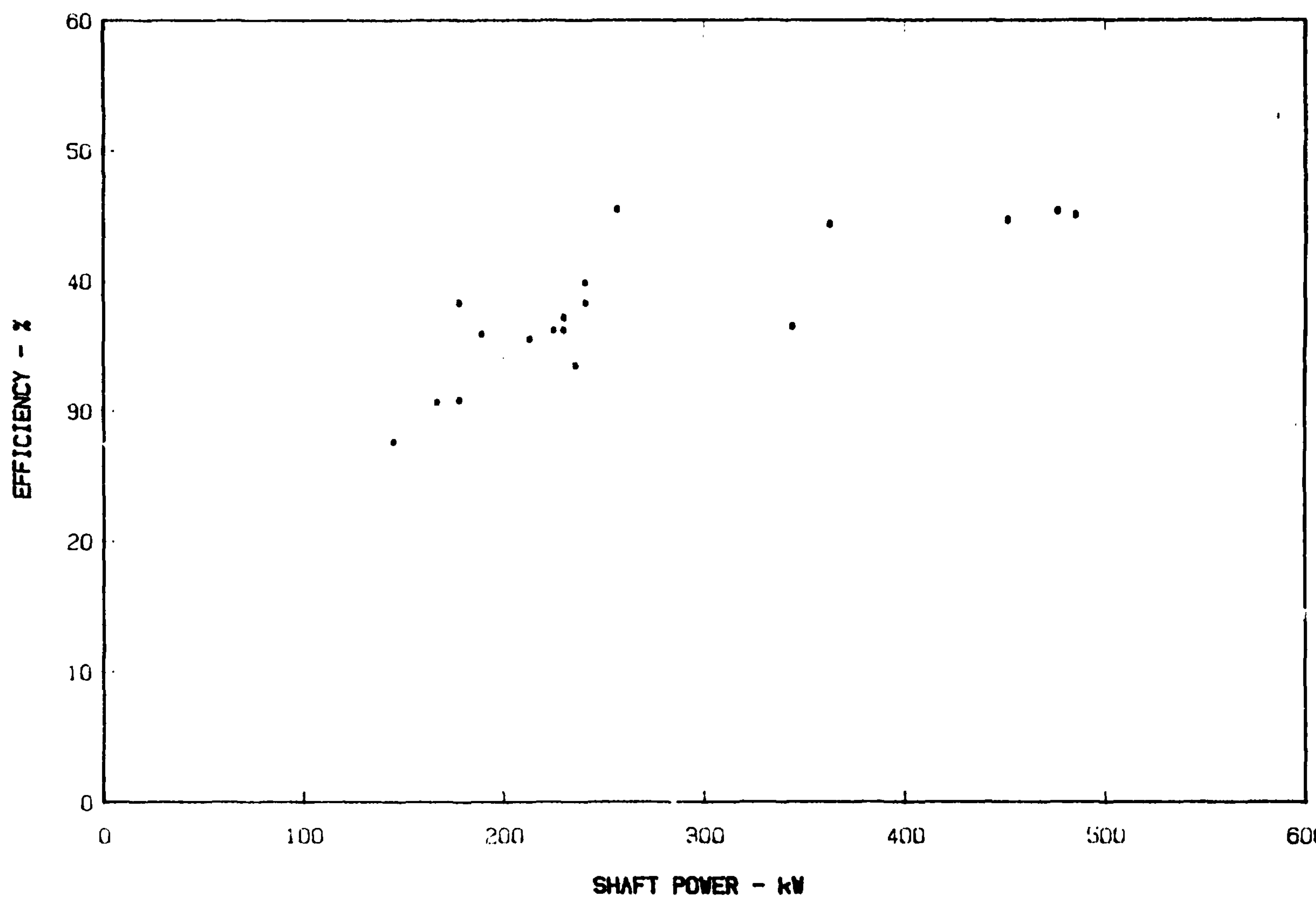


Figure B-1. Efficiency vs. Shaft Output Power (Ref. B., Fig. 10)

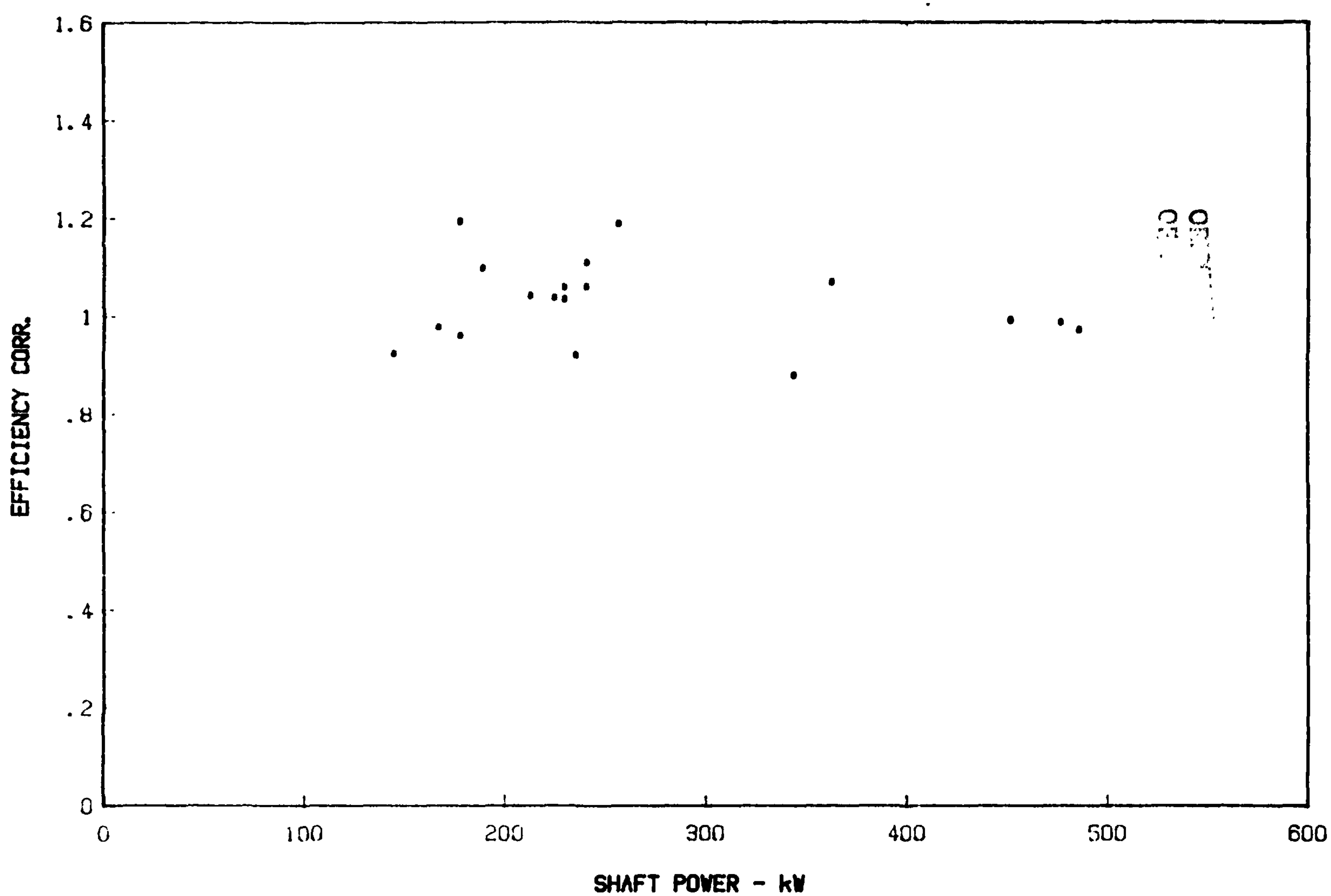


Figure B-2. Efficiency Correlation vs. Shaft Output Power (Ref. B., Fig. 8)

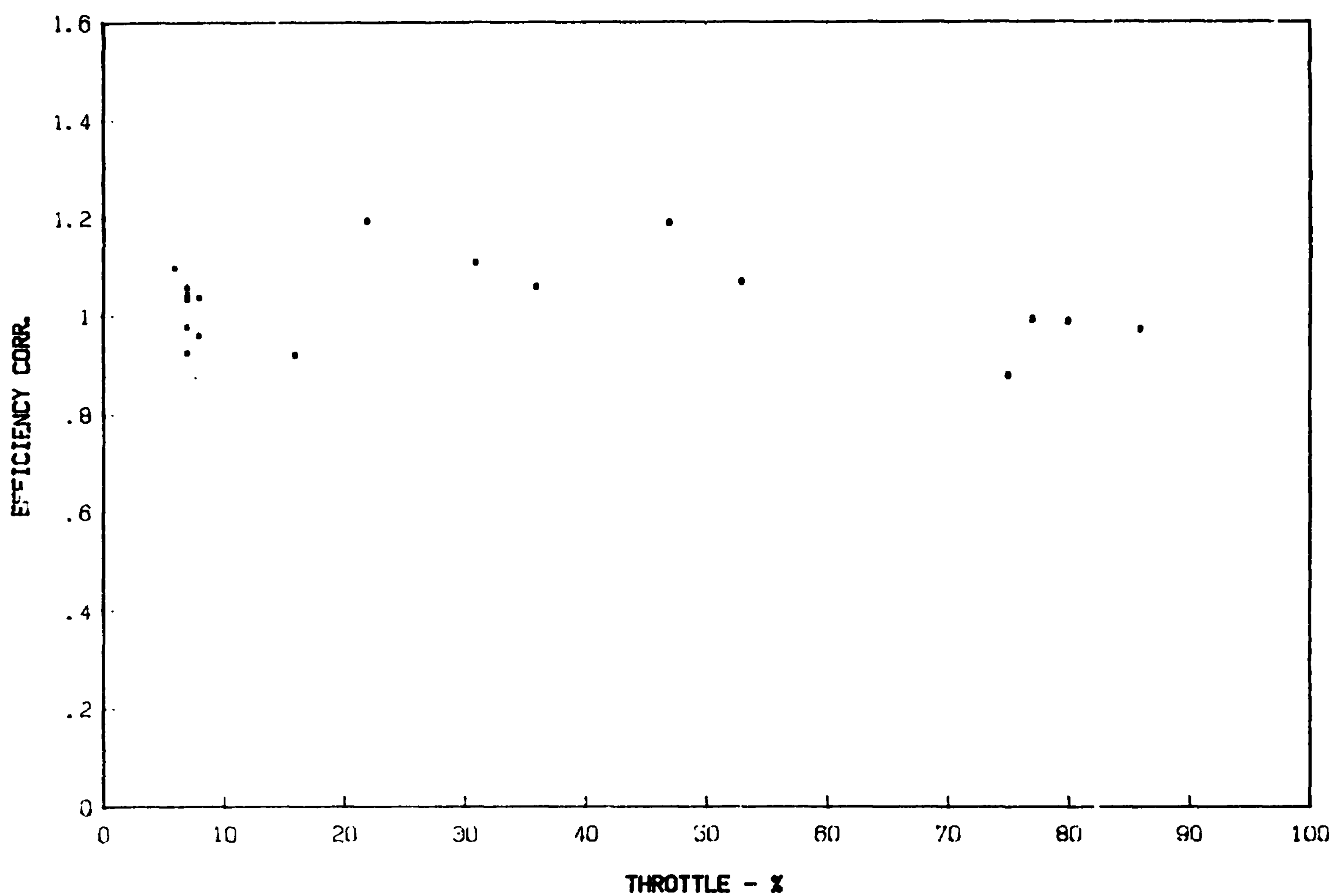


Figure B-3. Efficiency Correlation vs. Throttle Position (Ref. B., Fig. 9)

Table B-1. Chemical Characteristics of Cesano 1 Brine (Ref. B, Table 1)[1]

Chemical Constituents		p.p.m.
Calcium	Ca^{++}	366
Magnesium	Mg^{++}	6.4
Sodium	Na^{+}	53,800
Potassium	K^{+}	79,400
Lithium	Li^{+}	168
Iron	Fe^{++} +	
	Fe^{+++}	4.5
Ammonium	NH_4^{+}	11
Rubidium	Rb^{+}	296
Strontium	Sr^{++}	6.5
Cesium	Cs^{+}	55.4
Arsenic	As	1.8
Bicarbonate	HCO_3^{-}	9,580
Chloride	Cl^{-}	22,100
Sulfate	SO_4^{--}	147,400
Hydrogen sulfide	H_2S	33
Boric Acid	H_3BO_3	6,150
Silica	SIO_2	55.2
TDS		310,000

[1]Noncondensable gases were about 1% of the steady state mass flow rate, and consisted of more than 99% CO_2.

Table B-2. Nomenclature (Ref. B, Table 2)

SYMBOL	MEASURED DATA	
P_w	wellhead pressure	psia
P_f	liquid feed pressure	psia
P_2	HSE outlet pressure	psia
m_l	liquid flow-rate from separator	lb/hr
m_f	liquid flow-rate to HSE	lb/hr
m_v	steam flow-rate to HSE	lb/hr
th%	linear throttle position as percent of fully open	
P_s	separator pressure	psia
P_v	steam feed pressure	psia
P_1	HSE inlet pressure	psia
P_3	atmospheric pressure	psia
L_s	liquid level in separator	in.
t_s	separator temperature	°F
t_v	steam feed temperature	°F
t_1	HSE inlet temperature	°F
t_2	HSE outlet temperature	°F
t_3	atmospheric temperature	°F
V	generator voltage	V
I	generator current	a
freq	generator frequency	Hz
kW	generator power	kW

Table B-3. Chronology of Operations (Ref. B, pp. 21-25), Part 1 of 4

A. PILOT PLANT OPERATIONS

- The installation of the C1 pilot plant was finished at the end of July 1981 without mounting the HSE.

  The HSE arrived on the C1 site on July 20, 1981.

  The month of August was used for training staff.

- On August 25, 1981, the HSE mounting operations began.

- On September 9, 1981 the well production was started to carry out preliminary tests on the plant. After about 6 hours of operations the well was shut in because the separator discharged over the pit. It was necessary to place the separator discharge pipe under the water level in the pit.

- The stainless steel pipe that was lowered into the well to inject scaling inhibitor appeared broken when it was extracted from the well.

  A new pipe was lowered in the well.

- On September 18 the well was again put into production. After about 80 hours of production we were forced to shut in the well because the small pipe carrying scaling inhibitor in the well failed inside the well.

- It was tried to recover the pipe but without success. The pipe fell in the well.

- It was necessary to mount a drill rig and to proceed with fishing and cleaning operations.

- The cleaning operations began on 10/7 and were finished on 11/6.

- The HSE hook-up and calibration was finished on October 5th.

Table B-3. Chronology of Operations, Part 2 of 4

B. HSE OPERATIONS

1 - The HSE began to run on 11.18.1981. An attempt was made to start the plant with only steam coming from the separator. The steam quantity was not sufficient to maintain HSE operation because of separator limitations, and the plant stopped due to excessive vibrations tripping a safety switch. It was so decided to start utilizing the liquid phase. Strong vibrations were noted also in this latter case and an unexplainable noise.

2 - After a stop and after some modifications to the pipelines for HSE preheating, the HSE started up again with the plant directly connected with the well. The plant stopped again due to damage to the right fan of the load bank.

3 - Between 11-19 and 11-24 a bypass was installed to allow downstream preheating of HSE. The right fan was dismantled and repaired.

4 - From 11-24 to 11-26 the HSE again went into production both directly from the wellhead and from the separator. Many stops were necessary to clean the filter-basket upstream from the HSE. This clogged very fast due to scaling pieces coming from the pipeline upstream from the HSE (see Fig. 11). The load bank's right fan was damaged. The fan appeared to have run into the screen. The male shaft seal assemblies exhibited problems. The seal pressures, especially at the low pressure end, oscillated synchronously with the rotation of the rotor. The exhaust port and exhaust pipe showed a glaserite scale growth of about 2 cm/hr. The problem was partly reduced by injecting fresh water into the exhaust at the housing exhaust port.

5 - From 11-26 to 12-1 the valves of the plant were cleaned and the fan of load bank replaced.

6 - A new start-up was effected on 12-1 to verify the seals damage and to try to connect the generator with the grid. The HSE was connected with the grid without trouble from 8 pm to 22 pm.

An excessive oil consumption (>10 gal/hr) was noted. At 1 am the HSE was stopped to verify the seals damage.

7 - From 12-2 to 12-15 the seals were dismantled. "Removal of a damaged seal assembly revealed 5 out of 15 carbon segments were cracked.

Table B-3. Chronology of Operations, Part 3 of 4

The 5 cracked carbons were all fractured identically in the middle of the carbon segment with the fracture originating at a locking pin. According to R. Sprankle's opinion, "the cause of the fracture appears to be clearly related to the impacts on the rotor from large-scale fragments. The consensus is that the impact of the rotor causes the shaft to move abruptly, fracturing the midsection of the carbon." It was hence decided to repair the seals by utilizing the existing spare seal assemblies. The repair involved a change in the locking pins to reduce stress on the carbon segments and to provide a secondary port in the seal assembly allowing the recapture of any oil leakage should the carbons fail.

8 - From 12-15 to 2-22-1982, the valves, separators, and pipelines were cleaned. A new basket filter was designed and installed upstream from the HSE in order to avoid the many stops due to the basket clogging. The seals were modified in the USA according to Mr. Sprankle's suggestions. The data acquisition system was repaired from damage caused by a rat. A new pipeline between the wellhead and the HSE was installed.

9 - From 2-22 to 3-10, the repaired seals arrived and were mounted on the HSE.

10 - From 3-10 to 3-12, the HSE was put into production. At 5 pm on 3-10 the HSE was connected to the ENEL electrical grid. The maximum power produced with the separators working in parallel was about 460 kW. During the production the well began to clog. Notwithstanding the flushing of the exhaust pipe, it also began to clog. At 12 pm on 3-12 the well was shut in because of well clogging.

11 - From 3-12 to 3-23, the well was cleaned and the HSE discharge pipe was cleaned. Some injection tests on the well were carried out to verity its condition.

12 - 3-23: The HSE began production again and the generator was connected to the grid. A steadily increase in outlet pressure was noted from 1 to 1.2 bar. The clogging caused both a power reduction and the stiffening of the flex coupling mounted downstream the HSE.

It was decided to stop the expander and to clean again the dishcarge pipe. Pieces of scaling of a thickness of more than 10 cm were found (see Figs. 12, 13).

Table B-3. Chronology of Operations, Part 4 of 4

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13 - 3-24: The HSE was again in operation. It was tried to connect the HSE to the ENEL grid. Because of this operation the shear pins in the shear coupling failed.

14 - From 3-24 to 3-30, new shear pins for the shear coupling were constructed in the ENEL workshop of Larderello and again mounted on the HSE.

15 - From 30-3 to 31-3, the HSE was again connected to the wellhead to determine what the maximum producible power from C1 well was.

The maximum power was 550 KW. The load was reduced and the plant was operated with the two cyclones. The discharge pressure increased steadily and it was necessary to stop again and to clean exhaust pipe.

16 - 4-1: The HSE was again put into operation to determine the maximum producible power from the liquid phase. 260 kW was the power reached without liquid entrainment from separators.

All the objectives of the HSE tests were considered reached and the plant was shut in.

Table B-4. Unprocessed Data - Performance Test Results (Ref. B, Table 3), Part 1 of 15

TDS=360000 ppm, Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	Pi	Pf	Tv	Pv	Ps	Pw	P2	I	Mi	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File	
22 56	216.9	348.0	349.1	0.0	170.3	177.1	222	179.1	185	188	14.9	167	231	231	0.0	264	359	473	7	152	49.8	35.2	17	11.24.81
0 0	216.6	348.8	349.9	0.0	171.6	179.2	222	180.6	186	189	14.9	170	229	229	0.0	373	359	475	7	154	50.1	35.5	18	
0 0	216.6	348.8	349.9	0.0	171.6	177.6	222	180.5	186	189	14.9	168	228	228	0.0	144	360	474	7	154	50.0	35.6	19	
0 0	216.6	348.8	349.9	0.0	171.3	179.0	222	180.7	187	189	14.9	168	226	226	0.0	388	359	473	7	154	50.0	35.8	20	
0 0	216.6	348.8	350.0	0.0	170.2	177.8	222	180.6	187	190	14.9	168	227	227	0.0	245	359	473	7	154	49.9	35.8	21	
0 0	216.6	348.8	349.9	0.0	170.9	178.8	222	180.8	187	189	14.9	169	226	226	0.0	292	359	474	6	154	49.8	35.8	22	
0 0	216.6	348.8	350.0	0.0	171.1	179.0	222	180.7	187	189	14.8	168	227	227	0.0	317	359	474	6	153	49.7	35.3	23	
0 0	216.6	348.8	350.0	0.0	172.4	178.7	222	180.9	187	190	14.8	168	227	227	0.0	257	359	473	7	153	49.7	35.3	24	
0 0	216.6	348.9	350.0	0.0	172.1	179.3	222	180.7	187	189	14.8	168	229	229	0.0	324	360	474	6	153	49.9	35.0	25	
0 0	216.6	348.9	350.0	0.0	172.2	180.0	222	180.6	187	190	14.8	168	229	229	0.0	241	359	473	7	154	49.9	35.0	26	
0 0	216.6	348.9	350.0	0.0	171.0	178.6	222	180.8	187	189	14.9	169	229	229	0.0	404	358	473	7	153	50.0	35.3	27	
0 0	217.2	347.1	348.6	0.0	168.7	179.3	222	[illegible]	191	191	14.7	225	240	240	0.0	217	365	429	8	167	49.9	36.6	29	11.25.81
0 0	217.2	347.1	348.6	0.0	172.7	185.5	222	184.6	191	191	14.8	220	240	240	0.0	205	365	429	8	167	49.8	36.8	30	
0 0	217.2	347.1	348.6	0.0	175.1	183.1	222	184.4	191	191	14.7	220	241	241	0.0	216	365	428	8	167	49.9	36.4	31	
0 0	217.2	347.1	348.5	0.0	169.4	185.5	222	184.5	191	191	14.6	220	240	240	0.0	238	364	428	7	167	49.9	36.3	32	
0 0	217.1	347.1	348.5	0.0	166.1	178.5	222	184.6	191	191	14.7	221	240	240	0.0	188	365	430	8	167	49.8	36.5	33	
0 0	217.1	347.1	348.5	0.0	174.2	186.5	222	184.3	192	192	14.7	220	239	239	0.0	216	365	428	7	167	49.8	36.7	34	
0 0	217.2	347.1	348.5	0.0	170.8	183.0	222	184.3	191	191	14.7	221	240	240	0.0	226	365	429	7	167	49.9	36.5	35	
0 0	217.1	347.1	348.5	0.0	165.5	175.7	222	184.5	192	191	14.7	220	240	240	0.0	235	365	428	8	167	49.9	36.6	36	
0 0	21?	347.2	348.5	0.0	174.4	186.5	222	184.6	191	191	14.7	220	240	240	0.0	222	365	429	8	167	49.8	36.4	37	
11 [illegible]	217	[illegible]	348.5	0.0	170.9	184.2	222	184.5	192	191	14.7	220	241	241	0.0	226	364	429	7	167	49.8	36.4	38	
11 [illegible]	21?	[illegible]	348.5	0.0	171.4	183.5	222	184.5	191	191	14.7	220	239	239	0.0	224	365	428	8	167	49.8	36.6	39	
11 [illegible]	217.4	347.9	349.4	0.0	172.1	13.9	319	184.3	191	191	14.7	218	247	247	0.0	119	365	429	8	166	50.0	34.9	40	
0 0	217.4	348.0	349.5	0.0	174.8	13.9	274	184.5	191	191	14.7	217	246	246	0.0	81	366	429	8	166	50.1	34.9	41	
0 0	217.4	348.0	349.5	0.0	170.1	13.9	274	184.4	192	192	14.7	220	246	246	0.0	113	365	430	8	167	50.0	35.2	42	
0 0	217.4	348.0	349.4	0.0	169.7	13.9	274	184.7	191	192	14.7	220	246	246	0.0	92	366	429	9	167	50.1	35.1	43	
0 0	217.4	348.0	349.4	0.0	165.7	13.9	274	184.6	191	191	14.7	220	247	247	0.0	69	365	428	9	167	50.0	35.0	44	
0 0	217.4	348.0	349.4	0.0	167.7	13.9	274	184.5	191	191	14.7	220	248	248	0.0	109	366	428	9	168	50.0	35.0	45	
0 0	217.4	348.0	349.4	0.0	167.9	13.9	274	184.5	191	191	14.7	221	249	249	0.0	52	366	430	9	167	50.0	34.8	46	
0 0	217.4	348.0	349.5	0.0	171.9	13.9	274	184.3	191	192	14.7	221	250	250	0.0	67	366	430	9	167	50.1	34.6	47	
0 0	217.4	348.0	349.5	0.0	169.9	13.9	274	184.2	191	191	14.7	220	249	249	0.0	95	366	428	8	167	50.1	34.8	48	
0 0	217.4	348.0	349.5	0.0	170.3	13.9	273	184.5	191	192	14.7	220	247	247	0.0	95	366	428	9	167	50.1	35.0	49	
11 52	217.4	348.0	349.4	0.0	175.3	13.9	273	184.5	191	192	14.8	217	248	248	0.0	108	365	428	8	166	50.1	34.9	50	
11 58	217.4	348.0	349.5	0.0	171.6	13.9	274	184.5	191	192	14.7	219	248	248	0.0	99	366	429	9	166	50.1	34.8	51	
12 2?	215.4	343.8	352.0	1.4	169.9	184.6	362	184.9	188	177	14.5	219	177	173	3.6	346	364	429	20	166	49.3	45.9	52	
0 0	215.2	343.7	351.9	1.6	166.6	184.8	363	183.5	190	190	14.6	217	175	171	4.1	295	364	430	22	166	49.7	44.4	53	
0 0	215.2	343.6	351.9	1.7	165.9	183.6	363	184.8	190	190	14.6	217	177	172	4.4	314	364	428	22	166	49.7	44.0	54	
0 0	215.2	343.7	351.9	1.5	167.3	183.7	363	184.6	191	190	14.6	218	176	172	3.9	280	362	430	22	166	49.7	[illegible]	55	
0 0	215.2	343.7	351.9	1.6	168.2	183.5	363	184.1	191	191	14.6	217	176	172	4.1	302	364	428	21	165	49.7	44.2	56	

Table B-4. Unprocessed Data - Performance Test Results, Part 2 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	Ti	Qi	Pi	Pf	Tv	Pv	Ps	Pw	P2	I	Mi	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
0 0	215.2	343.7	351.9	1.3	166.8	183.6	363	183.9	191	190	14.4	217	175	171	3.4	323	364	429	22	166	49.8	45.9	57
0 0	215.2	343.7	352.1	1.6	166.8	184.8	363	184.3	191	190	14.6	217	176	172	4.2	289	364	428	21	165	49.7	44.1	58
0 0	215.2	343.8	351.9	1.5	166.2	184.2	363	184.6	190	190	14.6	217	175	171	3.9	279	363	428	22	166	49.7	45.2	59
0 0	215.2	343.9	352.1	1.5	166.2	183.8	363	184.2	191	190	14.7	218	175	171	3.9	298	363	430	22	166	49.7	45.4	60
0 0	215.2	343.9	352.0	1.7	167.4	184.1	363	184.1	191	190	14.6	218	175	171	4.4	326	363	430	22	165	49.7	43.9	61
12 54	215.2	343.9	352.0	1.3	165.6	183.3	363	183.6	191	170	14.7	217	176	172	3.5	330	364	428	23	161	49.7	44.6	62
12 54	215.2	343.8	352.0	1.6	166.6	184.0	363	184.0	190	190	14.6	219	176	172	4.0	311	363	429	22	166	49.7	44.7	63
13 24	215.0	344.4	351.8	1.7	166.2	183.9	364	184.1	190	190	14.7	220	175	171	4.2	283	364	429	22	167	49.8	44.5	64
13 55	214.9	344.3	351.7	1.6	166.8	184.3	364	184.7	191	191	14.8	221	176	172	4.1	288	365	429	22	166	49.9	44.9	65
14 25	214.[illegible]	344.5	351.8	1.6	166.6	184.4	364	184.3	191	191	14.7	221	177	173	4.2	289	364	429	22	167	49.9	44.0	66
14 55	214.9	345.0	350.2	1.4	166.5	184.4	361	184.5	200	191	14.6	221	178	175	3.5	280	363	429	22	167	50.0	45.7	67
15 30	214.8	344.8	349.8	1.5	166.4	184.6	358	184.6	200	191	14.7	220	181	178	3.6	286	363	429	22	167	50.0	46.2	68
16 0	215.2	349.0	353.7	1.8	165.8	184.0	363	184.8	191	192	14.6	220	174	170	3.9	300	363	429	23	167	49.9	42.4	69
16 30	215.1	348.9	353.6	1.9	165.3	184.8	363	184.7	191	192	14.7	220	174	170	4.0	286	362	429	23	167	49.8	42.4	70
17 0	215.0	349.3	353.9	2.0	164.7	184.7	364	184.5	191	192	14.7	221	174	169	4.0	264	363	429	24	167	49.8	41.9	71
17 30	215.1	349.2	353.8	1.9	164.3	184.6	364	184.5	191	192	14.7	220	174	170	4.0	276	363	429	24	167	49.8	41.7	72
0 0	216.8	356.3	357.2	0.0	167.3	183.8	327	184.2	191	191	14.7	169	191	191	0.0	311	363	428	7	128	50.3	32.4	73
0 0	216.9	356.6	357.6	0.0	164.9	183.1	325	187.5	190	191	14.7	169	194	194	0.0	267	364	428	7	128	50.2	31.9	74
0 0	216.9	356.6	357.6	0.0	165.0	182.0	325	183.7	190	192	14.7	168	195	195	0.0	275	364	428	7	128	50.2	31.6	75
0 0	216.9	356.6	357.6	0.0	168.1	184.0	325	184.4	190	191	14.7	168	195	195	0.0	280	364	427	7	128	50.2	31.6	76
0 0	216.9	356.6	357.6	0.0	163.9	182.8	325	182.7	190	191	14.7	169	195	195	0.0	282	364	429	7	128	50.2	31.6	77
0 0	216.9	356.6	357.6	0.0	164.9	182.1	325	183.5	190	191	14.7	168	196	196	0.0	284	364	429	7	128	50.2	31.6	78
0 0	216.9	356.6	357.6	0.0	167.4	183.3	325	184.6	190	191	14.7	168	196	196	0.0	303	363	427	7	128	50.2	31.6	79
0 0	216.9	356.6	357.6	0.0	168.0	185.1	325	183.9	190	191	14.7	168	196	196	0.0	296	364	428	7	128	50.2	31.6	80
0 0	216.9	356.7	357.6	0.0	164.1	181.3	325	182.6	190	191	14.7	170	197	197	0.0	288	363	430	7	128	50.2	31.3	81
0 0	216.9	356.7	357.6	0.0	164.2	184.1	325	182.1	190	191	14.7	169	196	196	0.0	293	363	430	7	128	50.2	31.5	82
0 0	216.9	356.7	357.6	0.0	166.8	182.8	325	184.8	190	191	14.7	169	196	196	0.0	299	363	427	7	128	50.3	31.4	83
0 0	205.3	344.7	344.1	0.0	153.0	167.5	316	169.3	191	192	14.7	154	179	179	0.0	295	364	389	7	116	49.8	38.2	84
23 6	216.2	355.1	358.2	2.1	169.5	186.0	366	186.4	192	194	15.1	317	202	197	4.5	241	367	428	29	241	50.0	46.3	85
0 0	216.5	351.6	355.9	2.2	167.6	184.8	366	187.0	193	193	15.5	318	205	200	5.2	248	367	429	31	239	50.0	47.3	86
0 0	216.5	351.2	356.4	2.3	166.3	186.0	367	187.5	194	193	14.7	318	206	200	5.4	294	366	430	31	241	49.9	45.2	87
0 0	216.6	351.3	355.9	2.1	165.8	187.3	366	186.8	193	194	15.1	316	204	199	4.9	296	366	428	30	239	50.0	47.0	88
0 0	216.5	351.1	356.4	1.9	166.8	185.0	367	187.9	193	174	14.6	319	204	199	4.6	269	366	429	31	241	50.0	46.9	89
0 0	216.5	351.4	355.9	1.8	167.3	187.1	366	186.6	193	193	15.1	316	202	198	4.4	272	367	428	30	240	50.0	48.3	90
0 0	216.9	351.2	355.9	2.1	167.3	185.0	367	187.7	193	194	14.6	316	203	198	5.0	298	366	428	31	244	50.0	46.7	91
0 0	216.7	351.4	355.9	2.2	168.3	185.2	366	187.3	193	194	15.2	316	203	198	5.2	271	367	427	31	240	50.0	47.2	92
0 0	216.9	351.1	355.9	2.0	169.8	184.2	366	186.4	193	194	14.6	316	203	198	5.0	269	366	428	31	244	50.0	46.6	93
0 0	216.5	351.5	355.9	2.4	164.3	187.5	366	187.1	193	193	15.1	316	203	198	5.3	266	367	427	31	240	49.9	46.4	94
23 30	216.6	351.2	356.3	2.0	168.0	184.5	367	187.8	193	194	14.6	318	204	199	5.0	311	365	431	32	241	50.0	46.1	95

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Table B-4. Unprocessed Data - Performance Test Results, Part 3 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File	
23 30	216.6	351.4	356.0	2.1	167.3	185.8	366	187.0	193	194	15.0	317	204	199	5.0	278	366	429	31	241	50.0	46.7	96	
23 41	216.7	351.0	355.9	1.9	167.3	185.9	367	187.3	193	194	14.6	318	207	202	4.8	306	366	430	31	242	50.0	46.0	97	
0 0	216.6	351.1	355.4	1.7	163.4	186.7	366	186.2	193	194	14.6	316	206	202	4.0	290	367	430	32	240	50.0	47.1	98	11.26.81
0 0	216.3	351.4	355.4	1.9	165.9	185.8	366	187.0	193	194	14.8	318	207	203	4.7	303	367	430	31	240	50.0	46.2	99	
0 0	216.3	351.0	355.9	2.1	167.8	185.8	366	187.5	193	193	14.7	323	206	201	5.1	309	365	430	32	240	50.0	45.8	100	
0 0	216.3	351.4	355.5	2.6	165.5	186.2	366	186.9	193	194	14.8	317	206	200	5.9	302	367	430	32	240	50.0	44.5	101	
0 0	216.3	351.0	355.9	2.0	163.8	185.1	366	187.8	193	193	14.6	321	207	202	4.6	284	365	430	33	240	49.9	46.3	102	
0 0	[illegible]	351.4	355.4	1.7	165.3	187.1	366	186.6	192	194	14.9	317	207	203	4.2	286	367	428	31	241	50.0	47.7	103	
0 0	[illegible]	351.0	355.4	1.7	164.8	186.1	366	186.3	193	194	14.6	316	208	204	4.2	310	366	429	31	243	50.0	47.0	104	
0 0	216.6	351.0	355.4	1.5	164.6	185.5	366	186.1	193	195	14.6	316	207	203	3.7	303	365	429	31	243	49.9	48.0	105	
0 0	216.3	351.0	355.9	1.6	167.6	185.0	366	186.2	193	193	14.7	321	209	205	4.1	279	365	431	32	240	50.0	46.9	106	
0 13	216.3	351.4	355.4	2.1	166.0	186.0	366	187.5	193	194	14.8	318	208	203	5.1	313	366	428	32	241	49.9	45.6	107	
0 30	216.3	351.4	355.2	2.0	164.3	185.9	366	186.4	192	194	15.0	317	209	205	4.8	280	366	429	33	242	49.8	46.3	108	
1 0	216.2	351.5	354.8	2.0	161.6	185.9	366	186.5	193	194	14.9	316	211	206	4.6	268	366	429	34	242	49.8	45.9	109	
1 30	216.0	351.4	354.8	2.1	161.0	184.6	367	185.5	192	193	14.8	317	212	207	4.9	287	365	429	35	242	49.8	44.8	110	
2 0	216.1	351.5	354.8	2.1	160.8	184.4	367	185.4	192	193	14.8	317	217	212	5.0	269	365	429	37	242	49.6	43.6	111	
2 30	216.0	351.7	354.1	2.1	160.6	184.8	367	185.8	192	193	14.8	318	213	208	4.8	300	365	429	36	242	50.2	44.6	112	
21 17	211.4	331.2	341.3	2.7	132.6	139.8	346	139.2	147	153	14.9	243	222	214	7.4	29	345	488	43	239	49.9	50.1	135	3.10.82
21 17	211.7	331.2	341.4	2.4	133.7	139.5	346	138.8	147	153	15.0	271	225	218	7.0	46	341	489	44	242	49.9	51.0	136	
21 18	211.9	331.1	341.4	3.2	132.6	139.8	346	138.8	148	154	14.9	280	197	190	7.4	38	347	486	44	261	49.9	58.0	137	
21 18	211.6	331.1	341.4	2.7	133.6	139.6	346	139.0	147	154	14.9	283	223	215	7.3	41	346	488	45	277	49.9	56.8	138	
21 18	211.9	331.3	341.4	2.8	133.2	[illegible]	346	138.9	147	153	14.9	275	213	206	7.3	44	345	489	44	269	49.9	57.1	139	
21 18	212.0	331.1	341.3	2.6	132.1	140.0	346	139.0	148	153	15.0	259	213	206	6.7	25	347	486	44	247	50.0	54.8	140	
21 18	212.1	331.0	341.3	2.7	133.1	139.2	346	138.8	147	154	15.0	283	245	237	8.1	19	343	488	45	277	49.9	52.2	141	
21 18	211.9	331.1	341.3	2.4	134.4	139.3	346	138.7	148	154	14.8	282	235	228	7.2	37	348	486	45	266	50.0	52.6	142	
21 18	212.1	331.3	341.3	2.6	133.0	139.5	346	138.9	148	153	14.9	281	234	226	7.5	35	341	487	45	268	50.0	53.0	143	
21 19	212.0	331.4	341.3	2.9	131.0	139.5	346	138.8	147	153	14.9	287	228	221	7.7	46	341	487	44	268	50.0	53.0	144	
21 31	211.8	331.2	341.4	2.4	133.3	139.7	346	139.0	147	154	14.9	273	244	237	7.4	41	344	487	44	270	50.0	51.9	145	
22 0	212.3	330.8	340.9	2.9	131.0	138.6	346	138.0	146	152	14.9	267	215	208	7.4	39	344	485	44	260	50.0	54.9	146	
22 30	212.4	329.8	339.9	2.7	129.5	136.4	345	135.9	145	151	14.8	281	231	224	7.5	40	342	485	47	262	49.9	52.8	147	
23 1	212.3	329.6	339.8	2.7	129.4	136.4	345	135.7	144	151	14.4	265	227	220	7.5	33	343	487	46	261	50.0	52.3	148	
23 31	212.4	329.0	339.2	2.8	127.8	135.2	344	134.5	143	150	[illegible]	274	223	21?	7.5	27	342	448	47	261	49.9	49.0	149	
0 1	212.6	328.7	339.0	2.7	127.0	134.7	344	133.9	143	149	14.8	272	232	225	7.5	30	342	447	47	263	50.0	53.7	150	3.11.82
0 31	212.3	328.2	338.5	2.6	127.0	133.5	343	132.8	142	148	14.9	277	237	230	7.6	27	341	449	48	258	49.9	52.2	151	
1 1	212.5	327.8	338.3	2.7	125.9	132.8	343	132.2	142	148	14.8	276	233	225	7.7	26	342	493	49	264	50.0	53.7	152	
1 32	212.4	327.6	338.0	2.7	125.0	132.1	343	131.6	141	147	14.9	323	234	226	7.5	28	341	497	49	255	49.9	52.5	153	
2 2	212.6	327.2	337.6	2.9	123.8	131.2	343	130.6	140	146	14.8	332	226	219	7.7	28	341	497	49	257	50.0	53.5	154	
2 33	212.4	327.4	337.6	2.8	123.8	130.8	343	130.1	15	146	14.8	288	231	223	7.7	25	341	493	50	258	49.9	52.2	155	
3 3	212.3	326.9	337.5	2.8	124.2	131.1	342	130.3	13	146	14.8	282	225	217	7.5	26	341	493	48	255	50.0	54.2	156	

Table B-4. Unprocessed Data - Performance Test Results, Part 4 of 15

TDS=360000 ppm, Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	θ1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
3 33	212.4	326.4	337.1	2.6	122.9	130.0	342	129.2	13	145	14.7	273	240	232	7.6	24	339	494	49	249	49.9	50.9	157
4 3	212.6	325.6	336.6	2.7	122.3	129.3	341	128.6	12	144	14.8	280	231	223	7.5	17	340	494	48	246	49.9	53.2	158
4 33	212.4	325.8	336.7	2.7	121.9	128.9	340	128.2	14	144	14.7	291	225	218	7.4	27	339	495	49	246	49.9	53.8	159
5 4	212.5	325.4	336.8	2.9	123.4	129.7	341	128.9	13	144	14.7	297	206	199	7.3	26	339	495	46	235	49.9	55.7	160
5 34	212.3	325.3	336.5	3.0	122.2	128.5	340	127.8	12	144	14.7	261	209	202	7.4	26	340	488	47	236	49.9	54.8	161
6 4	212.3	325.2	336.8	2.6	123.0	129.6	340	128.9	14	144	14.7	300	221	214	7.1	27	339	489	44	234	50.0	54.0	162
6 34	212.6	324.1	336.0	2.6	121.8	127.9	338	127.2	13	143	14.7	284	220	213	7.0	24	339	483	45	223	49.9	53.8	163
7 5	212.7	323.4	334.6	3.1	118.1	124.6	337	123.9	14	140	14.7	301	207	200	7.5	17	338	478	49	229	50.0	55.5	164
7 35	211.6	323.3	335.0	3.1	119.7	125.5	338	125.0	12	141	14.7	336	195	188	7.3	22	338	479	47	231	49.9	58.7	165
8 5	211.1	322.0	332.6	3.1	113.2	120.1	334	119.3	12	136	14.7	313	218	210	7.7	19	336	477	51	219	50.0	52.5	166
8 36	211.2	322.3	335.6	2.5	121.1	127.1	335	126.5	12	140	14.7	249	212	205	6.7	23	338	470	42	213	49.9	58.3	167
9 6	212.0	322.2	335.2	2.6	119.8	126.0	335	125.3	12	139	14.6	267	211	204	6.9	20	337	470	44	221	50.0	59.3	168
9 36	211.3	322.0	335.2	2.6	119.4	126.0	334	125.3	14	139	14.7	283	209	202	6.8	20	337	470	43	221	49.9	60.7	169
10 6	211.0	321.5	334.8	2.6	120.6	125.3	334	124.7	13	139	14.7	232	203	196	6.8	16	336	470	43	206	50.0	58.8	170
10 36	211.7	321.3	334.4	2.7	118.5	124.3	333	123.5	13	138	14.6	219	202	195	6.9	16	336	470	43	213	49.9	60.3	171
11 5	213.0	317.5	327.1	3.4	102.2	110.8	327	110.0	15	129	14.8	243	231	223	8.2	-0	331	475	68	230	49.9	56.8	172
11 5	213.0	317.5	327.0	3.8	103.4	110.4	327	109.7	14	128	14.6	223	216	207	8.5	15	330	474	68	215	49.9	54.6	173
11 5	213.0	317.5	326.9	4.2	101.8	110.7	327	109.6	13	128	14.8	244	200	192	8.4	5	329	474	69	253	49.9	66.5	174
11 5	213.0	317.6	326.9	4.1	100.4	110.7	327	109.7	13	128	14.8	235	206	198	8.4	4	332	475	69	236	49.9	61.5	175
11 5	213.0	317.5	326.9	3.7	104.0	110.4	327	109.7	12	128	14.8	246	216	208	8.5	4	330	474	69	219	49.9	55.8	176
11 6	213.0	317.4	326.9	4.0	103.9	110.6	327	109.6	13	128	14.6	249	199	191	8.3	7	331	476	69	242	49.9	64.3	177
11 6	213.0	317.4	326.8	4.3	102.1	110.1	327	109.2	14	129	14.8	265	195	187	8.5	5	328	478	70	235	50.0	62.9	178
11 6	213.0	317.5	326.7	3.8	101.8	109.7	327	109.3	13	128	14.6	243	217	209	8.4	0	328	477	69	232	50.0	58.4	179
1 6	213.0	317.5	326.7	3.4	102.3	110.2	327	109.7	13	128	14.8	274	233	225	8.3	-5	330	478	69	247	50.0	60.0	180
11 6	213.0	317.4	326.7	3.2	103.4	109.7	327	109.2	12	128	14.8	254	233	225	8.1	-0	334	476	69	241	50.0	59.1	181
11 6	213.0	317.5	326.8	3.7	103.0	110.2	327	109.5	13	128	14.7	251	220	212	8.4	5	331	476	69	231	50.0	58.0	182
12 6	210.3	316.9	326.7	3.2	102.7	110.2	327	109.4	12	128	14.7	239	244	235	8.4	3	331	439	69	179	49.9	44.1	183
12 10	210.0	316.7	326.6	3.7	99.4	109.7	327	109.2	11	128	14.6	280	224	216	8.3	-3	332	440	69	203	50.0	51.8	184
12 11	210.2	316.7	326.6	3.6	98.9	110.3	327	109.5	13	128	14.6	249	229	220	8.3	19	331	441	69	175	49.9	45.4	185
12 11	210.1	316.7	326.6	3.9	101.8	109.7	327	109.1	11	128	14.6	268	209	201	8.3	12	327	440	68	187	50.0	50.4	186
12 11	210.1	316.7	326.6	3.1	106.9	110.4	327	109.7	11	128	14.8	274	221	213	7.9	5	333	439	69	198	50.0	52.9	187
12 11	210.2	316.7	326.6	3.5	103.4		327	109.2	11	128	14.6	295	222	213	8.3	-0	334	440	68	210	50.0	53.8	188
12 11	210.3	316.9	326.6	3.2	104.6	[illegible].4	327	109.2	12	128	14.6	245	230	222	8.2	9	333	439	69	150	49.9	40.0	189
12 11	210.3	316.8	326.6	3.5	103.6	110.4	327	109.4	12	128	14.5	265	220	211	8.2	-10	333	439	69	192	49.9	49.9	190
12 11	210.1	316.9	326.6	3.3	102.3	109.8	327	109.6	12	128	14.6	262	231	223	8.0	-2	332	439	68	197	49.9	50.5	191
12 12	210.2	316.7	326.6	3.2	103.7	109.9	327	109.4	11	128	14.6	286	242	234	8.4	1	333	441	69	207	49.9	50.2	192
12 12	210.1	316.9	326.6	3.3	101.3	109.7	327	108.9	14	128	14.8	280	248	240	8.6	12	330	440	68	194	49.9	46.2	193
12 36	211.1	316.7	326.8	3.8	103.2	110.2	327	109.8	11	128	14.6	240	205	196	8.3	16	331	440	67	187	50.0	51.3	194
13 6	211.9	316.3	326.5	3.4	102.8	109.9	328	109.5	13	127	14.6	240	224	216	8.2	19	330	443	68	185	49.9	48.0	195

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Table B-4. Unprocessed Data - Performance Test Results, Part 5 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
13 36	212.0	316.2	326.7	3.3	102.4	109.9	328	109.4	11	127	14.6	251	230	222	8.1	23	331	444	66	183	49.9	46.8	196
14 6	211.9	315.1	325.1	3.4	100.1	107.6	325	107.3	13	126	14.7	287	228	219	8.3	19	329	443	69	180	49.9	48.0	197
14 36	211.5	314.6	322.6	3.9	95.2	104.2	323	103.7	12	123	14.6	208	231	222	8.7	13	328	437	77	179	49.9	46.1	198
15 6	212.5	313.5	322.0	3.9	95.5	103.4	323	103.1	12	123	14.6	240	220	211	8.6	14	327	440	77	184	49.9	50.0	199
15 36	211.7	313.2	322.9	3.7	97.2	104.2	323	104.1	13	123	14.6	237	218	210	8.4	9	327	438	71	167	50.0	47.4	200
16 [illegible]	209.4	313.0	323.4	3.4	97.8	104.9	324	104.7	12	123	14.6	232	221	213	8.2	7	328	438	69	173	50.0	48.9	201
16 [illegible]	209.7	312.4	323.6	3.4	98.1	105.4	324	105.2	13	123	14.6	224	221	213	8.1	-27	328	441	68	170	50.0	49.0	202
17 6	209.4	312.2	324.2	3.6	99.0	106.0	324	105.7	12	124	14.6	251	207	199	8.1	1038	328	443	66	167	50.0	50.4	203
17 36	208.7	312.0	323.[illegible]	3.4	98.1	104.6	323	104.1	12	122	14.6	229	215	207	7.9	-26	327	442	66	160	49.9	48.1	204
18 [illegible]	207.7	311.6	323.0	3.6	97.0	104.0	323	103.2	11	122	14.5	209	209	201	8.0	-16	327	439	65	147	50.1	43.3	205
18 22	209.4	311.3	321.7	4.1	92.1	101.2	322	100.2	13	120	14.6	225	215	206	8.6	-49	327	435	71	167	49.9	47.5	206
18 22	209.2	311.2	321.3	3.9	91.6	101.3	322	100.7	13	120	14.6	218	218	209	8.4	17	326	435	71	155	49.9	45.4	207
18 22	209.2	311.2	321.3	3.4	96.2	101.9	322	101.0	14	120	14.5	216	222	214	8.3	12	325	435	72	161	49.9	46.2	208
18 22	209.3	311.1	321.2	3.4	94.7	102.1	322	100.7	13	120	14.5	231	227	219	8.2	2	325	434	71	162	49.9	46.2	209
18 23	209.6	311.1	321.3	3.3	96.2	101.7	322	101.2	14	120	14.5	209	224	216	8.2	46	325	435	72	154	49.9	44.9	210
18 23	209.5	311.3	321.3	3.7	95.8	101.9	322	100.6	14	120	14.5	232	215	207	8.5	-48	327	436	71	161	49.9	46.4	211
18 23	210.1	311.3	321.3	3.6	96.0	101.6	322	100.7	13	120	14.5	243	216	207	8.3	-43	328	434	71	172	49.9	49.4	212
18 23	209.7	311.2	321.3	4.0	91.8	101.3	322	100.6	14	120	14.5	238	216	208	8.5	19	328	437	71	153	49.9	44.5	213
18 23	209.4	311.1	321.3	3.5	94.2	102.1	322	100.9	12	120	14.5	220	217	209	8.1	7	329	434	71	146	50.0	43.8	214
18 23	209.5	311.0	321.2	3.7	93.3	101.9	322	100.6	14	120	14.6	216	219	210	8.4	10	329	436	72	139	49.9	41.5	215
18 36	209.7	311.0	320.8	3.8	93.3	101.0	321	100.2	13	120	14.6	254	215	206	8.3	-1	326	436	72	153	49.9	45.6	216
19 7	208.9	310.5	320.2	3.8	92.6	100.1	321	99.3	13	119	14.6	200	213	205	8.3	5	326	431	72	153	49.9	46.4	217
19 37	209.8	309.0	318.6	3.9	89.7	98.0	319	97.2	15	117	14.6	214	215	206	8.4	-24	324	434	75	153	49.9	46.6	218
20 8	209.8	308.6	318.9	3.6	91.0	98.5	319	97.6	14	117	14.6	186	214	206	8.1	-37	324	434	72	144	49.9	45.2	219
20 38	211.3	308.0	318.1	3.7	89.4	97.4	319	96.5	13	116	14.6	185	214	205	8.2	-18	324	437	73	143	49.9	45.5	220
21 8	211.6	307.3	317.0	4.1	88.2	95.5	317	94.5	12	115	14.6	192	203	194	8.3	-29	323	438	74	133	49.9	44.2	221
21 39	211.5	306.7	316.5	4.1	87.1	94.7	317	93.8	16	114	14.6	171	205	196	8.3	-36	322	440	75	134	50.0	44.4	222
22 10	212.0	306.1	315.8	4.0	86.4	93.9	316	93.0	15	114	14.6	177	204	196	8.3	-38	321	442	75	130	49.9	44.0	223
22 40	212.7	305.7	315.5	4.1	86.4	93.4	316	92.5	17	113	14.6	191	202	194	8.3	-39	321	440	76	130	49.9	44.8	224
23 10	212.4	305.5	315.5	4.1	85.7	93.6	316	92.6	17	113	14.6	179	203	195	8.4	-46	321	440	75	128	49.9	43.6	225
23 31	213.0	305.0	315.1	4.1	84.3	93.2	316	92.0	24	112	14.6	164	202	193	8.2	-32	323	443	76	132	49.9	45.9	226
23 31	212.9	305.1	315.0	4.1	85.1	92.6	316	91.6	23	112	14.5	174	202	194	8.3	-28	322	442	76	119	49.9	41.5	227
23 31	213.0	305.1	315.0	4.0	85.2	92.9	316	92.0	19	112	14.6	190	205	196	8.2	-35	321	444	75	154	49.9	51.5	228
23 31	212.9	305.0	315.0	4.0	86.0	92.7	316	91.5	19	112	14.5	185	205	196	8.4	-1	325	442	75	137	49.9	45.7	229
23 31	212.9	305.0	315.0	3.9	86.8	92.8	316	91.8	23	112	14.5	178	202	193	8.2	-45	324	444	76	143	49.9	48.5	230
23 31	212.9	305.0	315.0	4.3	84.2	92.8	316	91.6	21	113	14.6	151	198	190	8.4	-41	322	442	76	112	49.9	40.4	231
23 31	212.8	305.0	314.9	4.2	86.4	93.1	316	91.8	25	112	14.5	176	196	187	8.3	-32	322	444	75	116	49.9	41.7	232
23 31	212.8	305.0	314.9	4.5	82.3	92.6	316	91.6	25	113	14.5	157	196	187	8.4	-57	322	442	76	136	49.9	46.7	233
23 31	212.9	305.0	315.0	4.1	86.1	93.1	316	92.1	20	112	14.6	178	193	185	8.1	-19	321	443	76	127	49.9	46.1	234

Table B-4. Unprocessed Data - Performance Test Results, Part 6 of 15

TDS=360000 ppm,Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	Ti	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	Mi	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
23 31	212.9	305.0	315.0	4.3	85.3	91.9	316	91.2	22	112	14.6	170	195	187	8.4	-46	322	442	76	131	49.9	45.3	235
23 40	212.9	304.9	315.0	4.0	84.9	92.8	316	91.7	24	112	14.6	179	204	196	8.3	-40	320	445	75	119	49.9	42.0	236
0 11	213.5	305.0	315.4	4.0	86.0	93.2	316	92.1	31	112	14.6	175	199	191	8.2	-39	322	445	74	125	49.9	44.2	237
0 42	212.8	304.0	314.6	4.1	84.8	91.8	315	90.7	33	111	14.6	164	197	188	8.1	-40	320	442	74	118	50.0	43.3	238
1 12	212.5	302.7	313.4	4.1	83.3	90.1	314	89.1	28	110	14.6	183	194	185	8.1	-36	318	441	73	113	50.0	43.2	239
1 43	212.7	302.5	313.2	4.0	83.1	90.1	314	88.8	27	109	14.6	157	198	190	8.1	-41	318	440	74	109	50.0	41.6	240
2 13	212.3	302.5	313.1	4.1	83.1	89.9	314	88.7	27	109	14.6	168	197	189	8.2	-40	317	442	75	116	50.0	43.4	241
2 44	212.5	301.4	312.0	4.0	82.3	88.3	312	87.1	31	108	14.6	162	193	185	8.0	-29	317	442	74	110	49.9	43.2	242
3 14	211.9	301.2	312.7	3.8	83.0	89.5	313	88.3	13	109	14.6	158	197	189	7.9	-31	318	442	74	106	49.9	42.2	243
3 45	211.8	300.8	311.7	4.1	81.4	87.6	312	86.5	13	107	14.6	162	191	183	8.0	-35	318	443	74	108	50.0	43.3	244
4 15	211.2	299.6	310.9	4.0	80.5	87.1	312	86.0	12	107	14.6	160	193	185	8.0	-32	318	442	75	106	50.0	43.3	245
4 46	211.5	299.3	310.3	4.2	79.7	86.0	311	84.8	13	106	14.6	166	187	179	8.0	-22	317	443	74	100	49.9	42.5	246
5 17	211.5	299.5	310.7	4.2	79.6	86.5	311	85.3	13	106	14.7	155	189	181	8.0	-34	317	441	74	96	49.9	41.0	247
5 47	211.4	298.6	310.1	4.1	79.5	85.5	310	84.2	13	105	14.6	173	186	178	7.9	-38	316	440	73	99	50.0	42.9	248
7 2	211.2	297.1	306.7	4.2	78.4	83.2	309	82.4	16	103	14.5	169	182	174	8.0	-58	313	433	74	65	49.9	32.8	249
7 2	211.2	297.1	308.7	4.4	75.3	83.6	309	82.7	15	103	14.6	175	183	175	7.9	-29	316	432	74	85	50.0	40.1	250
7 2	211.1	297.2	308.8	4.5	76.2	83.3	309	82.2	16	103	14.5	178	176	168	7.9	-34	315	434	74	96	49.9	43.5	251
7 2	211.2	297.4	308.7	4.8	74.0	83.1	309	81.9	16	103	14.6	178	177	169	8.0	7	319	434	74	108	49.9	47.0	252
7 2	211.2	297.5	308.6	4.6	74.0	82.8	309	81.9	16	103	14.6	176	177	169	8.0	-68	320	434	74	85	49.9	39.6	253
7 3	211.2	297.6	308.6	4.5	76.2	82.7	309	81.9	17	104	14.6	175	182	174	8.0	-62	319	434	74	78	49.9	36.8	254
7 3	211.2	297.6	308.6	4.7	74.0	82.6	309	81.9	17	103	14.5	181	181	173	8.0	-64	314	434	74	103	49.9	44.5	255
7 3	211.2	297.5	308.7	4.1	80.0	83.3	309	82.4	16	103	14.5	178	180	172	7.9	-8	312	434	74	86	49.9	40.1	256
7 3	211.2	297.4	308.7	4.5	76.5	83.4	309	81.8	17	103	14.5	169	180	172	8.0	-19	314	434	74	76	49.9	36.0	257
7 3	211.4	297.3	308.6	4.1	77.4	83.3	309	82.4	17	103	14.5	176	188	180	7.9	-4	313	434	74	94	49.9	41.8	258
7 35	210.4	296.9	308.7	4.2	77.5	83.4	309	82.3	15	103	14.6	170	181	173	7.8	-29	315	425	73	88	49.9	41.2	259
8 5	210.9	296.7	308.1	4.4	76.2	82.4	308	81.4	14	102	14.6	111	177	169	7.9	-27	314	418	74	87	49.9	41.2	260
9 2	210.8	295.1	306.9	4.3	75.3	81.0	307	80.2	13	101	14.6	112	177	169	7.8	-37	313	432	73	82	50.0	41.1	261
9 5	210.7	294.9	306.7	4.3	75.2	80.7	307	79.8	13	101	14.7	122	176	168	7.8	-24	312	432	74	76	49.9	39.5	262
9 7	210.8	294.6	306.6	4.9	71.0	80.0	307	79.4	12	101	14.5	129	171	163	7.8	-23	316	431	73	78	50.0	39.9	263
9 8	210.7	294.9	306.6	4.3	75.9	81.2	307	79.8	12	101	14.5	133	173	166	7.7	5	315	431	73	82	50.0	41.3	264
9 8	210.8	294.7	306.6	4.2	76.4	81.1	307	79.9	15	100	14.5	127	175	167	7.8	-62	314	433	74	69	50.0	36.9	265
9 8	210.9	294.6	306.6	4.2	75.4	81.3	307	80.1	13	101	14.6	123	174	167	7.7	12	314	431	74	50	49.9	31.1	266
9 8	210.8	294.6	306.7	4.2	76.3	80.7	307	80.2	15	101	14.6	136	175	167	7.7	5	311	433	73	94	49.9	46.3	267
9 8	210.8	294.8	306.5	4.6	73.1	80.4	307	79.8	13	100	14.6	116	172	165	7.8	4	312	431	73	78	49.9	40.4	268
9 8	210.8	294.9	306.6	4.2	76.0	80.8	307	80.2	16	100	14.5	130	174	167	7.7	-68	313	430	73	92	49.9	45.3	269
9 8	210.8	294.8	306.7	4.4	73.3	80.6	307	80.2	13	101	14.5	134	177	170	7.7	-66	313	432	72	103	49.9	48.9	270
9 9	210.7	294.7	306.7	4.2	75.4	81.1	307	80.2	13	101	14.6	118	176	168	7.6	9	317	430	74	68	49.9	37.3	271
9 9	210.7	294.6	306.7	4.2	76.7	80.8	307	79.8	16	100	14.5	129	175	167	7.8	4	314	432	73	71	49.9	37.4	272
9 19	210.6	294.6	306.5	4.3	74.9	80.5	307	79.7	12	100	14.6	116	175	167	7.8	-19	313	431	74	74	49.9	38.6	273

3.12.82

Table B-4. Unprocessed Data - Performance Test Results, Part 7 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File	
9 29	210.4	294.3	306.3	4.2	75.3	80.3	306	79.5	13	100	14.8	125	175	168	7.7	-24	312	431	73	75	49.9	39.7	274	
9 40	211.9	295.9	318.2	2.6	97.2	99.8	317	99.2	13	113	14.5	25	137	131	5.6	-28	321	427	24	12	50.3	25.4	275	
9 50	212.7	301.8	319.7	1.8	99.9	102.9	319	101.9	14	115	14.6	29	151	147	4.4	-32	324	427	22	14	50.5	25.0	276	
10 3	212.9	300.6	319.0	1.7	100.3	102.3	318	101.5	12	114	14.6	14	148	144	4.1	-35	323	426	20	6	50.5	22.6	277	
10 58	220.5	353.5	356.1	3.0	158.6	174.4	362	173.5	183	188	15.3	537	344	334	9.9	141	359	430	80	435	49.9	44.3	278	
11 1	220.4	353.5	356.1	2.9	160.3	175.9	362	175.3	184	189	15.8	536	345	335	10.0	185	365	434	81	437	49.9	45.9	279	
11 3	220.4	353.5	356.3	2.9	160.9	176.1	362	175.6	184	189	15.8	541	343	333	9.8	202	360	433	80	447	49.9	47.1	4	3.23.82
11 3	220.4	353.4	356.2	2.7	160.5	176.3	362	175.1	184	189	16.0	521	341	332	9.1	220	366	433	80	422	50.0	46.2	5	
11 3	220.4	353.4	356.1	3.1	160.1	175.1	362	174.8	184	189	15.7	523	342	332	10.4	187	364	435	80	433	49.9	44.9	6	
11 3	220.4	353.4	356.1	3.1	160.2	175.0	362	174.7	184	190	15.9	541	346	335	10.5	171	364	436	80	444	49.9	45.9	7	
11 3	220.4	353.4	356.0	3.2	158.1	175.2	362	174.8	185	189	15.8	522	351	340	10.8	158	367	436	80	426	49.9	43.2	8	
11 3	220.4	353.4	356.1	3.1	161.4	176.0	362	175.1	185	190	15.8	523	356	345	11.1	84	373	435	80	429	49.9	42.8	9	
11 3	220.4	353.5	356.3	2.7	161.2	176.8	362	176.3	185	190	15.8	534	350	340	9.5	150	367	435	80	429	49.9	45.2	10	
11 3	220.4	353.4	356.4	2.7	162.6	176.7	362	176.2	185	190	15.9	534	343	334	9.5	205	361	434	80	432	49.9	46.5	11	
11 3	220.4	353.4	356.3	3.0	160.3	175.6	362	175.3	185	189	15.8	528	342	332	10.2	176	361	434	80	434	49.9	45.5	12	
11 3	220.4	353.4	356.2	3.1	158.9	176.5	362	175.6	185	189	15.9	525	342	332	10.2	137	363	434	80	425	49.9	45.0	13	
11 5	220.4	353.6	356.1	2.9	160.4	175.8	362	175.2	184	189	15.8	537	343	333	9.7	211	369	434	80	439	50.0	46.4	14	
11 5	220.4	353.6	356.2	2.8	160.0	176.2	362	175.7	184	189	15.8	525	342	332	9.3	156	371	435	80	434	50.0	46.5	15	
11 5	220.5	353.5	356.3	3.0	159.1	176.1	362	175.4	184	189	15.9	543	342	332	9.9	182	361	433	80	437	50.0	46.5	16	
11 5	220.4	353.5	356.2	3.4	159.4	174.8	362	174.6	185	189	15.7	534	345	333	11.3	202	361	433	80	434	50.0	43.7	17	
11 5	220.5	353.5	356.1	3.1	160.2	175.5	362	174.9	184	189	15.9	531	347	336	10.6	160	360	433	80	431	50.0	44.7	18	
11 5	220.5	353.5	356.1	2.9	159.2	176.3	362	175.4	185	189	16.0	528	348	338	9.9	108	360	433	80	435	50.0	45.9	19	
11 5	220.4	353.4	356.2	2.8	160.0	176.3	362	176.3	184	189	15.9	537	348	338	9.5	212	360	437	80	445	50.0	47.3	20	
11 5	220.4	353.3	356.3	2.8	162.5	176.6	362	176.1	185	189	15.9	547	344	334	9.8	220	361	433	79	447	50.0	47.6	21	
11 5	220.5	353.4	356.2	2.9	162.4	176.5	362	175.7	185	189	15.9	543	342	332	10.2	207	370	434	80	445	49.9	47.1	22	
11 5	220.5	353.5	356.2	2.9	159.6	175.8	362	175.1	185	189	15.9	525	343	333	9.6	168	361	433	79	423	50.0	45.3	23	
11 57	219.9	353.5	355.6	3.0	158.7	175.2	362	174.9	15	189	16.0	660	356	345	10.4	16	369	444	86	442	50.0	45.5	24	
11 57	219.9	353.5	355.5	3.2	158.0	174.7	362	174.2	12	189	15.9	647	357	346	11.0	-27	373	444	86	443	49.9	44.3	25	
11 57	220.0	353.6	355.6	2.9	158.9	175.3	362	175.1	14	189	15.9	644	355	345	9.8	36	370	442	86	445	50.0	46.0	26	
11 57	219.9	353.6	355.6	3.1	158.4	175.2	362	174.4	14	189	15.7	662	353	343	10.4	-41	364	442	86	454	49.9	45.8	27	
11 57	219.9	353.7	355.6	3.0	160.6	175.2	362	175.2	14	189	15.9	679	354	344	10.4	30	361	442	86	460	49.9	47.0	28	
11 57	219.9	353.9	355.6	3.0	157.7	175.0	362	174.7	14	189	15.7	645	353	343	9.8	-14	366	441	86	438	50.0	44.8	29	
11 58	219.9	353.7	355.7	3.3	157.7	174.6	362	174.4	15	188	15.7	653	352	341	10.8	14	362	441	85	453	50.0	45.3	30	
11 58	219.9	353.6	355.7	2.9	159.9	175.1	362	174.8	15	188	16.0	637	351	341	10.0	-20	358	441	86	423	50.0	44.4	31	
11 58	219.9	353.7	355.5	2.9	158.0	175.0	362	174.4	14	189	16.0	653	349	339	9.7	14	365	442	86	444	50.0	46.8	32	
11 58	219.9	353.7	355.4	3.0	157.8	174.2	362	174.0	15	189	15.8	650	351	341	10.1	8	361	443	86	422	50.0	43.5	33	
11 58	220.0	353.6	355.6	3.1	157.8	174.8	362	174.4	14	189	15.9	641	355	345	10.5	-2	365	442	86	438	50.0	44.7	34	
12 12	219.8	353.2	355.4	3.0	157.7	174.8	362	174.2	13	189	15.9	665	354	344	10.3	44	364	443	86	441	50.0	45.3	35	
12 15	219.8	353.3	355.4	3.1	157.6	175.2	361	174.6	13	189	15.8	658	353	343	10.5	7	366	442	86	435	49.9	44.5	36	

Table B-4. Unprocessed Data - Performance Test Results, Part 8 of 15

TDS=360000 ppm,Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	Ti	Qi	Pi	Pf	Tv	Pv	Ps	Pw	P2	I	Mi	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
12 15	219.[illegible]	353.3	355.4	3.1	157.0	174.6	362	173.8	12	189	15.9	663	352	341	10.2	95	370	442	86	446	49.9	46.0	37
12 15	219.8	353.3	355.4	3.1	158.6	175.0	362	174.3	14	189	15.9	666	352	342	10.5	33	364	442	86	443	49.9	45.5	38
12 15	219.8	353.2	355.4	3.1	156.7	175.0	362	173.9	13	188	15.9	656	350	339	10.4	57	360	442	86	437	49.9	45.3	39
12 15	219.8	353.3	355.3	3.2	157.7	174.6	362	173.3	13	189	15.9	655	352	341	10.7	64	359	442	86	436	49.9	44.4	40
12 15	219.8	353.3	355.4	3.3	157.7	174.3	362	173.9	12	189	15.9	661	354	343	11.0	30	360	442	85	441	49.9	44.5	41
12 15	219.8	353.2	355.3	3.0	157.4	174.7	362	174.2	13	189	15.8	667	355	345	10.2	48	359	442	86	436	49.9	44.7	42
12 15	219.8	353.2	355.3	3.3	154.4	174.2	361	173.3	13	189	15.9	659	354	344	10.7	48	359	442	86	438	49.9	44.5	43
12 15	219.8	353.2	355.3	3.2	158.1	175.0	362	173.8	13	189	16.0	656	357	346	11.2	30	361	442	86	435	49.9	43.8	44
12 16	219.8	353.2	355.4	3.1	156.2	174.7	361	173.9	13	189	16.0	656	357	347	10.3	54	361	442	85	436	49.[illegible]	44.8	45
12 22	219.8	353.2	355.3	3.0	157.5	174.8	361	174.1	13	189	15.9	644	354	344	10.2	36	365	440	86	437	49.9	45.0	46
12 32	219.9	353.3	355.4	3.0	157.9	174.6	361	174.2	13	189	15.[illegible]	26	355	345	10.3	10	366	438	86	429	50.0	44.0	47
12 43	219.4	352.9	356.1	2.9	160.1	175.7	362	175.3	13	189	15.8	592	342	333	9.8	197	364	438	79	413	50.0	44.6	48
12 53	218.9	352.8	356.2	2.8	160.6	175.7	361	175.4	13	189	15.7	602	337	328	9.7	216	364	442	76	409	49.9	44.8	49
13 0	219.0	353.0	356.1	2.7	160.4	176.0	361	175.6	13	189	15.9	602	343	334	9.3	140	361	442	77	409	49.9	44.9	50
13 0	219.0	352.9	356.2	2.8	161.2	175.7	361	175.3	13	[illegible]	15.8	591	337	327	9.7	211	360	441	77	408	49.[illegible]	44.7	51
13 0	219.0	352.9	356.2	3.0	158.9	175.0	361	174.7	13	188	15.8	609	336	326	9.9	190	369	443	77	412	49.9	44.9	52
13 0	219.0	353.0	356.1	2.9	159.5	175.1	361	174.7	13	188	15.7	602	339	329	9.7	173	366	442	77	409	50.0	44.3	53
13 0	219.0	353.0	356.0	2.8	161.0	175.1	361	175.2	15	189	15.9	608	339	329	9.5	167	367	442	77	416	49.9	45.8	54
13 0	219.0	353.0	356.1	2.6	159.4	175.0	361	174.6	13	188	15.8	606	340	331	8.8	156	359	443	77	406	50.0	45.0	55
13 0	219.0	353.0	356.1	3.0	160.1	175.5	361	174.9	13	189	15.7	599	343	333	10.1	105	368	441	77	407	50.0	43.3	56
13 0	219.0	353.0	356.2	2.6	161.6	175.8	361	175.4	13	189	15.7	606	342	333	9.2	144	370	444	77	412	49.9	44.9	57
13 0	219.0	353.0	356.2	2.7	160.9	176.1	361	175.6	13	189	15.8	617	340	331	9.1	173	369	442	77	422	49.9	46.4	58
13 0	219.0	352.9	356.2	2.7	160.0	175.5	361	175.1	13	189	15.7	607	340	331	9.3	180	363	444	77	416	49.9	45.4	59
13 3	219.0	352.9	356.1	2.8	160.1	175.5	361	175.1	13	189	15.7	602	338	329	9.6	165	365	442	77	409	49.9	44.5	60
13 14	219.0	353.0	356.1	2.8	159.8	175.3	361	174.9	183	189	15.8	594	341	332	9.6	144	366	441	77	403	49.9	43.7	61
13 24	219.1	353.0	356.2	2.8	159.9	175.3	362	175.0	184	189	15.9	597	341	332	9.6	120	363	441	77	405	49.9	44.1	62
13 34	219.3	353.0	356.1	2.9	159.7	175.2	362	174.8	184	189	15.9	607	337	327	9.7	97	365	441	78	407	49.9	44.6	63
13 44	219.6	353.0	356.2	2.8	159.9	175.4	362	175.0	184	189	15.9	606	338	329	9.5	121	365	439	77	405	49.9	44.7	64
13 54	219.6	353.0	356.2	2.8	160.6	175.6	361	175.4	184	189	15.9	598	335	325	9.5	135	364	440	76	402	50.0	44.9	65
14 4	219.6	353.2	356.2	2.9	159.6	175.1	362	174.6	183	188	16.0	633	336	327	9.6	-5	363	440	77	401	49.9	44.3	66
14 14	219.6	353.3	356.2	2.9	159.4	175.1	361	174.7	184	189	16.0	603	338	328	9.6	-6	365	432	77	401	49.9	44.1	67
14 24	219.7	353.0	356.0	2.9	159.7	175.2	361	174.9	184	189	16.1	589	338	328	9.6	-1	366	432	77	398	49.9	44.2	68
14 34	220.0	353.1	356.0	2.9	159.2	175.0	361	174.5	184	189	16.1	607	337	328	9.6	1	364	435	78	395	49.9	43.9	69
14 44	220.1	353.4	356.0	2.9	159.8	175.2	361	174.7	184	189	16.3	600	335	325	9.6	-7	365	434	77	395	49.9	44.4	70
14 54	220.0	353.3	356.0	2.9	159.5	175.3	361	174.8	184	189	16.3	602	334	325	9.6	-8	369	437	76	387	49.9	43.7	71
15 4	219.9	353.4	356.0	2.9	159.2	174.9	361	174.5	184	189	16.[illegible]	599	336	327	9.5	-15	363	436	76	388	50.0	43.7	72
15 14	220.4	352.8	355.9	2.8	160.1	175.6	361	175.0	184	189	16.5	590	337	328	9.3	124	362	435	76	380	49.9	43.7	73
15 25	221.0	353.0	355.9	2.8	159.7	175.1	361	174.5	184	189	16.4	582	338	328	9.4	68	363	435	76	370	49.9	42.2	74
15 35	220.9	353.1	356.0	2.9	159.7	175.0	361	174.5	183	189	16.2	542	334	325	9.5	62	366	430	76	365	49.9	41.5	75

Table B-4. Unprocessed Data - Performance Test Results, Part 9 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	iv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File	
15 45	220.7	352.9	355.9	2.8	159.4	175.1	361	174.6	184	189	16.1	536	334	325	9.4	68	365	430	75	362	49.9	41.1	76	
15 55	220.6	353.0	356.0	2.8	159.6	175.0	361	174.5	184	189	16.1	554	336	326	9.5	63	365	434	75	358	49.9	40.5	77	
16 5	220.6	352.9	355.9	2.8	159.9	175.0	361	174.6	184	189	16.1	512	334	325	9.3	66	365	433	75	353	49.9	40.4	78	
16 15	220.7	352.8	355.9	2.8	159.9	175.2	361	174.7	184	189	16.2	514	334	324	9.4	85	362	436	75	348	49.9	40.1	79	
16 25	220.7	352.8	355.8	2.8	159.9	175.1	361	174.4	184	189	16.2	508	333	323	9.3	111	362	435	75	345	49.9	40.0	80	
16 43	220.8	352.7	356.0	2.8	159.4	175.0	361	174.2	183	189	16.3	507	335	326	9.4	114	366	438	75	341	49.9	39.2	81	
17 29	221.3	352.5	356.0	2.7	160.1	175.3	361	174.3	184	189	16.6	481	335	325	9.2	193	364	441	75	320	50.0	37.9	82	
17 57	221.3	352.3	356.0	2.7	160.3	175.4	361	174.6	183	189	16.8	463	335	326	9.1	306	365	441	75	313	50.0	37.7	83	
18 7	221.4	352.1	356.0	2.6	160.5	175.3	361	174.5	183	189	16.7	443	336	326	9.1	296	366	441	74	304	50.0	36.8	84	
18 17	221.4	352.2	355.8	2.7	159.4	175.0	361	174.1	183	189	16.7	458	335	326	9.2	229	363	441	75	301	49.9	36.4	85	
18 27	221.4	352.1	355.8	2.7	160.0	175.2	361	174.3	95	189	16.6	460	335	326	9.2	223	362	436	75	301	49.9	36.2	86	
23 20	214.3	341.1	344.2	0.0	173.0	178.7	222	178.5	12	194	14.9	267	295	295	0.0	-31	368	401	8	185	50.0	36.0	88	3.25.82
23 20	214.2	341.0	344.2	0.0	173.9	179.7	222	177.7	11	195	14.9	267	288	288	0.0	3	368	401	8	185	49.9	36.8	89	
23 20	214.3	341.1	344.3	0.0	177.4	183.5	222	180.4	12	195	15.0	267	301	[illegible]	0.0	6	368	401	8	185	49.9	35.5	90	
23 20	214.3	341.0	344.3	0.0	173.8	180.5	222	179.2	11	195	15.0	266	293	293	0.0	-15	368	400	8	185	49.9	36.6	91	
23 20	214.3	341.1	344.2	0.0	173.4	178.2	222	176.6	13	195	14.9	270	298	298	0.0	5	368	399	8	185	50.0	35.6	92	
23 20	214.3	341.1	344.2	0.0	173.6	179.6	222	181.8	12	195	14.9	266	297	297	0.0	-13	369	399	8	185	50.0	35.8	93	
23 20	214.3	341.1	344.2	0.0	173.5	179.8	222	177.1	12	195	14.9	266	299	299	0.0	-9	368	399	8	185	49.9	35.6	94	
23 20	214.3	341.0	344.2	0.0	173.3	180.3	222	180.6	12	195	14.9	266	295	295	0.0	12	369	399	8	185	49.9	36.0	95	
23 20	214.3	341.0	344.2	0.0	172.9	178.5	222	177.7	12	194	14.9	266	295	295	0.0	-18	369	399	8	185	49.9	36.1	96	
23 25	214.3	341.3	344.4	0.0	175.6	180.9	222	180.9	13	195	14.9	266	292	292	0.0	-4	366	399	8	185	49.9	36.3	97	
23 29	214.3	341.3	344.4	0.0	172.0	178.0	222	179.5	14	194	14.9	266	289	289	0.0	16	368	399	8	185	50.0	36.5	98	
23 29	214.3	341.3	344.6	0.0	174.9	179.7	222	181.0	14	195	14.9	267	287	287	0.0	-7	367	399	8	185	50.0	36.9	99	
23 29	214.3	341.3	344.5	0.0	176.2	182.0	222	181.4	14	195	14.9	266	298	298	0.0	-11	368	399	8	185	50.0	35.5	100	
23 29	214.3	341.3	344.5	0.0	175.3	181.7	222	185.1	13	195	14.9	270	290	290	0.0	-4	368	399	8	185	50.0	36.5	101	
23 29	214.3	341.3	344.5	0.0	177.0	181.3	222	180.4	13	196	15.0	266	296	296	0.0	10	368	399	8	185	50.0	36.0	102	
23 29	214.3	341.3	344.5	0.0	176.0	181.5	222	183.2	13	196	14.9	266	292	292	0.0	-19	367	399	8	185	50.0	36.2	103	
23 29	214.3	341.3	344.5	0.0	174.8	181.3	222	179.9	13	196	14.9	266	290	290	0.0	-2	368	399	8	185	50.0	36.4	104	
23 29	214.3	341.3	344.6	0.0	177.2	181.8	222	180.7	13	196	14.9	266	290	290	0.0	-5	368	400	8	185	49.9	36.4	105	
23 29	214.3	341.2	344.5	0.0	177.0	182.0	222	182.9	13	196	14.9	266	283	283	0.0	-1	367	400	8	185	50.0	37.3	106	
23 29	214.3	341.2	344.5	0.0	175.7	181.1	222	180.4	13	196	14.9	267	294	294	0.0	-7	368	400	8	185	50.0	36.0	107	
23 30	214.1	341.2	344.4	0.0	176.8	181.9	222	181.8	13	196	14.9	249	291	291	0.0	-4	367	419	8	181	50.0	35.7	108	
23 50	213.8	340.3	343.4	0.0	177.5	181.7	222	179.8	12	195	14.8	230	287	287	0.0	35	367	430	7	173	50.0	35.0	109	
23 50	213.7	340.3	343.5	0.0	177.2	181.1	222	180.1	16	195	14.8	231	282	282	0.0	44	366	431	7	172	50.0	35.6	110	
23 50	213.7	340.3	343.5	0.0	174.5	180.5	222	179.9	16	195	14.8	230	284	284	0.0	32	366	430	7	173	50.0	35.4	111	
23 50	213.7	340.2	343.6	0.0	173.4	178.8	222	179.5	16	195	14.8	230	282	282	0.0	50	366	430	7	173	50.0	35.7	112	
23 50	213.7	340.2	343.5	0.0	172.9	177.6	222	179.0	16	195	14.8	229	282	282	0.0	24	366	430	8	173	50.1	35.7	113	
23 50	213.7	340.2	343.6	0.0	175.8	181.7	222	179.5	16	195	14.8	230	285	285	0.0	47	366	431	7	173	50.0	35.4	114	
23 50	213.7	340.2	343.5	0.0	179.0	183.8	222	180.0	16	195	14.8	231	285	285	0.0	37	367	431	7	173	50.0	35.3	115	

Table B-4. Unprocessed Data - Performance Test Results, Part 10 of 15

TDS=360000 ppm,Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	Ti	Qi	Pi	Pf	Tv	Pv	Ps	Pw	P2	I	Mi	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
23 50	213.8	340.2	343.4	0.0	175.0	183.2	222	179.5	16	195	14.8	230	283	283	0.0	17	367	430	7	173	50.0	35.5	116
23 50	213.8	340.2	343.4	0.0	177.7	184.7	222	178.9	16	195	14.6	229	280	280	0.0	27	366	430	7	173	50.0	35.7	117
23 50	213.8	340.2	343.4	0.0	177.7	182.8	222	180.0	15	195	14.8	229	286	286	0.0	2	366	429	7	173	50.1	35.2	118
0 17	213.6	338.9	342.2	0.0	178.6	185.2	222	180.0	11	195	14.8	216	259	259	0.0	275	366	401	6	150	49.8	35.5	119
0 17	213.6	339.1	342.2	0.0	181.5	185.2	222	180.5	13	195	14.8	216	259	259	0.0	292	365	401	6	150	49.9	35.3	120
0 17	213.6	339.1	342.2	0.0	177.5	182.0	222	178.7	13	195	14.8	216	256	256	0.0	278	365	400	6	150	49.9	35.8	121
0 17	213.6	339.1	342.2	0.0	173.9	181.2	222	179.7	12	195	14.8	216	257	257	0.0	279	364	399	6	151	49.9	35.7	122
0 17	213.5	339.1	342.2	0.0	180.9	186.0	222	180.6	12	195	14.9	216	255	255	0.0	302	363	399	6	151	49.8	36.3	123
0 17	213.4	339.1	342.2	0.0	177.0	182.3	222	180.1	12	195	14.9	216	259	259	0.0	294	363	400	6	151	49.9	35.7	124
0 17	213.5	339.1	342.2	0.0	176.9	182.8	222	179.6	12	195	14.9	216	259	259	0.0	272	364	401	6	150	49.9	35.5	125
0 17	213.5	339.2	342.2	0.0	179.0	182.6	222	179.8	12	195	14.9	216	253	253	0.0	264	365	401	6	150	49.9	36.5	126
0 17	213.5	339.1	342.2	0.0	179.6	184.5	222	179.3	12	195	14.9	216	256	256	0.0	285	364	401	6	150	49.9	36.1	127
0 17	213.5	339.1	342.2	0.0	173.9	178.5	222	178.0	12	195	14.8	216	256	256	0.0	284	365	399	6	151	50.0	35.8	128
0 18	213.5	339.1	342.2	0.0	177.9	182.1	222	179.4	12	195	14.8	216	256	256	0.0	283	365	400	6	150	49.9	35.9	129
0 19	213.4	338.9	342.2	0.0	179.8	184.8	222	180.3	16	195	14.9	216	255	255	0.0	272	367	402	6	150	49.9	36.4	130
0 19	213.5	339.0	342.2	0.0	182.8	184.3	222	180.0	12	195	14.9	216	259	259	0.0	271	366	401	6	150	49.9	35.5	131
0 19	213.5	339.1	342.2	0.0	175.8	182.3	222	178.8	13	195	14.8	216	259	259	0.0	288	366	401	6	151	49.9	35.4	132
0 19	213.5	339.1	342.2	0.0	178.6	185.9	222	179.5	13	195	14.8	216	256	256	0.0	309	366	400	6	150	49.9	35.8	133
0 19	213.4	339.0	342.2	0.0	175.3	184.6	222	180.0	13	195	14.9	216	260	260	0.0	309	366	400	6	151	49.9	35.7	134
0 19	213.5	339.1	342.2	0.0	174.6	180.8	222	179.7	13	195	14.8	216	260	260	0.0	307	366	399	6	151	49.9	35.3	135
0 19	213.5	339.0	342.2	0.0	178.4	183.8	222	179.3	13	195	14.9	216	252	252	0.0	296	367	400	6	151	49.9	36.8	136
0 20	213.5	338.9	342.2	0.0	177.6	182.1	222	180.2	13	195	14.9	216	259	259	0.0	290	367	400	6	150	49.9	35.7	137
0 20	213.5	338.9	342.2	0.0	181.0	184.1	222	180.3	13	195	14.8	216	259	259	0.0	271	366	400	6	150	49.9	35.5	138
0 20	213.6	338.9	342.1	0.0	174.1	179.3	222	180.0	13	195	14.9	216	253	253	0.0	286	366	402	6	150	49.9	36.6	139
0 37	214.1	348.1	351.1	0.0	179.4	180.2	222	179.9	12	195	14.9	267	267	267	0.0	146	365	410	7	190	50.0	36.5	140
0 37	214.1	348.2	351.2	0.0	180.2	186.1	222	179.0	13	194	14.9	267	262	262	0.0	194	365	411	7	190	50.0	37.1	141
0 37	214.1	348.2	351.2	0.0	174.2	179.6	222	179.4	12	194	14.9	269	263	263	0.0	159	367	409	7	190	50.1	37.0	142
0 38	214.1	348.3	351.2	0.0	172.7	179.7	222	180.5	12	194	14.8	267	263	263	0.0	192	366	409	7	191	50.0	36.8	143
0 38	214.1	348.3	351.2	0.0	170.7	179.6	222	178.5	12	195	14.9	266	269	269	0.0	202	366	409	7	190	50.1	36.1	144
0 38	214.1	348.3	351.2	0.0	176.1	185.9	222	178.8	12	194	14.8	268	265	265	0.0	184	367	411	7	190	50.0	36.3	145
0 38	214.1	347.8	351.2	0.0	171.8	180.0	222	178.9	12	194	14.9	267	261	261	0.0	194	367	409	7	191	50.1	37.6	146
0 38	214.1	346.8	351.3	0.0	170.8	173.6	222	179.7	12	195	14.9	267	264	264	0.0	224	366	408	7	190	50.1	37.7	147
0 38	214.1	345.8	351.3	0.0	180.0	176.5	222	180.5	12	195	14.9	267	264	264	0.0	210	367	410	7	190	50.0	38.1	148
0 38	214.0	345.1	351.3	0.0	172.2	180.6	222	177.8	12	194	14.9	267	260	260	0.0	219	368	409	7	190	50.1	39.1	149
0 53	214.0	353.0	356.0	0.0	177.4	182.1	222	181.6	11	195	14.9	267	254	254	0.0	241	366	411	7	190	50.0	35.7	150
0 53	214.2	352.9	356.0	0.0	178.2	181.5	222	180.4	12	195	14.9	266	253	253	0.0	240	367	409	7	190	50.1	35.9	151
0 53	214.2	352.9	355.9	0.0	177.9	180.8	222	181.1	11	195	14.9	266	255	255	0.0	216	367	409	7	190	50.0	35.6	152
0 53	214.1	352.9	356.0	0.0	175.2	180.1	222	181.5	11	195	14.9	267	252	252	0.0	260	367	411	7	190	50.0	36.0	153
0 53	214.2	352.9	356.0	0.0	176.7	177.3	222	180.6	12	194	14.9	267	253	253	0.0	271	367	410	7	190	50.0	35.9	154

3.26.82

Table B-4. Unprocessed Data - Performance Test Results, Part 11 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
0 53	214.2	352.9	355.9	0.0	173.9	181.1	222	180.5	12	195	14.9	266	253	253	0.0	215	367	409	7	191	50.0	35.9	155
0 53	214.2	352.9	356.0	0.0	180.0	181.7	222	181.0	11	194	14.9	265	252	252	0.0	236	367	409	7	191	49.9	36.0	156
0 53	214.2	353.0	356.0	0.0	175.9	178.0	222	180.0	11	195	14.9	266	251	251	0.0	271	367	409	7	191	50.0	36.2	157
0 54	214.2	353.0	356.0	0.0	178.9	185.7	222	180.7	11	195	14.9	266	250	250	0.0	248	367	408	7	191	50.0	36.4	158
0 54	214.2	352.9	356.0	0.0	177.3	180.8	222	181.4	11	195	14.9	266	251	251	0.0	241	367	409	7	190	50.0	36.2	159
0 54	214.1	352.9	356.0	0.0	177.8	181.7	222	180.8	12	195	14.9	266	252	252	0.0	254	367	410	7	190	50.0	36.0	160
1 24	215.6	353.0	356.0	0.0	175.9	181.0	222	180.8	13	194	15.0	266	259	259	0.0	279	368	410	7	190	50.0	35.1	161
1 54	215.9	352.9	356.1	0.0	177.2	181.8	222	182.1	13	194	14.9	266	263	263	0.0	164	368	409	7	190	49.9	34.5	162
2 24	215.8	352.6	355.7	0.0	176.8	182.3	222	181.1	13	194	14.9	266	260	260	0.0	222	368	409	7	190	49.9	35.2	163
2 54	216.0	352.2	355.3	0.0	178.4	182.8	222	184.6	13	195	14.9	267	255	255	0.0	247	365	409	7	190	50.0	36.0	164
3 24	215.6	352.0	355.1	0.0	178.0	183.6	222	184.3	12	194	14.9	266	259	259	0.0	242	365	409	7	191	49.9	35.6	165
3 54	215.8	351.9	355.0	0.0	179.7	183.6	222	184.2	14	194	14.9	266	255	255	0.0	233	365	409	7	191	50.0	36.2	166
4 24	215.9	351.8	354.8	0.0	177.5	182.2	222	183.9	14	194	14.9	267	254	254	0.0	239	364	409	7	191	50.0	36.4	167
4 54	216.3	351.6	354.7	0.0	177.5	183.0	222	183.5	15	194	14.9	267	251	251	0.0	334	363	410	7	191	50.1	36.9	168
5 24	215.8	351.7	354.8	0.0	177.7	184.2	222	183.4	12	194	14.9	267	252	252	0.0	296	364	410	7	191	50.0	36.8	169
5 54	216.0	351.8	354.9	0.0	178.6	183.3	222	183.5	14	194	15.0	267	250	250	0.0	234	363	410	6	191	50.1	37.2	170
6 24	216.0	351.7	354.9	0.0	179.5	182.4	222	183.1	13	194	15.0	267	252	252	0.0	230	364	410	7	191	50.2	37.0	171
6 54	216.1	351.8	354.8	0.0	177.3	181.9	222	183.3	12	194	15.0	266	254	254	0.0	186	364	410	7	191	50.1	36.6	172
7 24	215.7	351.7	354.9	0.0	178.0	182.0	222	183.2	12	194	14.9	267	251	251	0.0	185	363	409	7	191	50.1	36.9	173
7 54	217.0	351.7	354.9	0.0	177.4	182.8	222	183.2	13	194	14.8	267	250	250	0.0	137	364	410	7	190	50.1	36.8	174
8 24	216.6	351.6	354.6	0.0	178.7	181.4	222	182.7	13	194	15.0	266	254	254	0.0	109	365	410	7	190	50.0	36.6	175
8 54	216.2	351.7	355.0	0.0	178.3	183.6	222	182.9	12	194	14.9	265	253	253	0.0	226	367	410	6	189	50.0	36.4	176
9 24	216.0	351.5	354.5	0.0	176.3	182.0	222	182.9	13	194	14.9	266	251	251	0.0	127	364	410	6	191	50.1	37.0	177
9 54	215.8	351.3	354.5	0.0	176.2	181.2	222	183.5	12	194	14.9	267	255	255	0.0	93	368	410	7	190	50.0	36.4	178
10 24	155.8	349.1	255.6	0.0	43.5	186.3	222	184.3	13	194	14.7	16	43	43	0.0	382	363	90	18	11	45.9	46.5	179
18 1	217.9	351.7	357.2	0.0	149.7	171.5	222	179.0	14	186	14.8	244	281	281	0.0	17	357	461	17	196	49.7	33.3	199
18 1	217.9	351.9	357.2	0.0	151.5	173.0	222	179.0	14	186	14.8	243	282	282	0.0	1	356	460	16	197	49.9	33.3	200
18 1	217.9	352.0	357.3	0.0	152.0	172.5	222	179.1	12	186	14.8	244	281	281	0.0	15	356	461	15	198	49.8	33.5	201
18 1	217.8	351.9	357.4	0.0	150.3	173.6	222	179.1	13	187	14.8	242	279	279	0.0	23	356	458	16	195	49.8	33.4	202
18 1	217.8	351.9	357.5	0.0	150.3	173.0	222	179.1	12	186	14.8	242	280	280	0.0	15	355	459	16	196	49.8	33.4	203
18 1	217.9	351.9	357.7	0.0	150.1	172.8	222	179.1	13	187	14.8	244	281	281	0.0	-7	356	461	17	198	49.8	33.6	204
18 1	217.9	351.9	357.7	0.0	151.1	173.1	222	178.8	12	187	14.8	243	280	280	0.0	9	355	461	16	198	49.8	33.7	205
18 1	217.9	351.9	357.8	0.0	150.0	173.0	222	179.2	13	186	14.8	242	280	280	0.0	11	355	459	17	196	49.8	33.4	206
18 1	217.9	351.8	357.8	0.0	149.6	172.3	222	179.1	14	187	14.8	243	280	280	0.0	16	356	459	16	196	49.8	33.5	207
18 1	217.9	351.8	357.7	0.0	148.5	173.1	222	179.2	13	186	14.8	242	282	282	0.0	18	355	459	17	196	49.7	33.3	208
18 5	217.8	351.8	357.7	0.0	150.3	172.7	222	179.2	13	187	14.8	243	281	281	0.0	46	356	460	16	196	49.8	33.4	209
18 6	217.3	352.8	359.5	0.0	153.5	173.7	222	179.6	13	187	14.6	243	271	271	0.0	109	356	458	15	195	50.0	33.7	210
18 7	217.4	351.8	358.7	0.0	149.6	171.2	222	179.6	13	187	14.8	243	272	272	0.0	110	356	460	16	197	49.8	34.5	211
18 7	217.5	351.6	358.4	0.0	151.9	173.2	222	179.4	12	187	14.8	242	273	273	0.0	110	357	459	16	196	49.8	34.4	212

3.30.82

Table B-4. Unprocessed Data - Performance Test Results, Part 12 of 15

TDS=360000 ppm;Inert gasses=38 0 wt% of vapor

TIME	T2	Tf	Ti	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	Mi	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
18 7	217.5	351.6	358.2	0.0	149.9	172.5	222	179.6	15	187	14.8	242	275	275	0.0	123	357	460	16	196	49.7	34.2	213
18 7	217.6	351.7	358.1	0.0	152.4	172.6	222	179.3	13	187	14.6	242	276	276	0.0	124	356	459	15	196	49.9	33.8	214
18 7	217.6	351.5	357.9	0.0	149.1	172.2	222	179.4	15	187	14.8	241	276	276	0.0	117	356	461	16	196	49.7	34.0	215
18 7	217.6	351.5	357.9	0.0	148.8	173.8	222	179.3	14	187	14.8	242	277	277	0.0	116	357	460	16	195	49.8	33.8	216
18 7	217.7	351.5	357.7	0.0	149.1	172.6	222	179.3	15	187	14.8	243	279	279	0.0	103	356	461	17	195	49.8	33.7	217
18 7	217.7	351.6	357.7	0.0	152.5	174.2	222	179.3	13	187	14.6	243	283	283	0.0	95	357	461	16	195	49.9	32.9	218
18 7	217.7	351.5	357.7	0.0	150.9	172.0	222	179.6	15	187	14.8	243	282	282	0.0	114	355	459	16	196	49.9	33.4	219
18 7	217.7	351.7	357.9	0.0	150.4	172.7	222	179.3	14	187	14.7	243	279	279	0.0	89	356	460	16	196	49.8	33.6	220
18 37	216.9	350.8	356.3	0.0	157.5	172.9	222	179.4	13	190	14.8	244	291	291	0.0	-13	360	461	19	197	50.0	32.8	221
19 8	217.7	352.1	358.0	0.0	153.8	170.0	222	173.5	12	188	14.9	240	294	294	0.0	115	360	453	16	190	49.9	31.2	222
19 42	217.6	351.7	357.7	0.0	157.5	172.7	268	37.8	13	189	14.9	240	293	293	0.0	110	360	453	14	191	50.0	31.5	224
19 42	217.7	351.9	357.7	0.0	157.1	171.7	266	36.6	15	188	15.0	241	294	294	0.0	56	360	453	15	191	49.9	31.6	225
19 42	217.6	351.9	357.7	0.0	156.6	171.6	266	36.4	13	189	14.9	240	295	295	0.0	141	360	453	15	191	50.0	31.2	226
19 42	217.6	351.8	357.8	0.0	154.7	170.0	266	36.3	13	189	14.8	241	295	295	0.0	73	361	455	16	191	50.0	31.1	227
19 42	217.6	351.9	357.8	0.0	156.7	170.3	266	36.1	13	189	15.0	240	294	294	0.0	53	360	453	16	192	50.0	31.8	228
19 42	217.6	351.9	357.8	0.0	156.7	171.0	265	35.9	13	188	14.9	240	294	294	0.0	94	360	453	15	191	50.0	31.4	229
19 42	217.6	351.9	357.8	0.0	157.7	172.7	265	35.7	12	189	14.9	241	293	293	0.0	64	361	455	14	191	50.0	31.5	230
19 42	217.6	351.9	357.8	0.0	155.6	171.7	265	35.5	13	188	14.9	242	294	294	0.0	104	361	453	15	191	50.0	31.4	231
19 42	217.6	351.9	357.8	0.0	156.7	169.8	264	35.3	15	189	14.9	242	295	295	0.0	85	361	455	16	191	50.0	31.2	232
19 42	217.6	351.9	357.8	0.0	155.3	171.5	264	35.3	13	189	15.0	240	296	296	0.0	36	362	454	16	191	49.9	31.4	233
20 9	215.4	353.1	355.7	3.6	148.1	174.1	368	173.4	12	189	14.9	403	242	234	7.4	2	365	454	59	320	49.9	42.5	234
20 39	215.8	352.1	359.4	3.[illegible]	158.6	174.7	369	174.0	13	189	15.0	405	248	240	8.0	138	366	454	53	322	49.9	41.3	235
21 9	215.5	352.0	359.9	3.2	160.3	175.2	366	174.5	11	189	14.9	405	237	229	7.7	165	365	454	48	322	50.1	45.1	236
21 39	215.8	353.0	360.0	3.4	157.8	174.4	364	173.5	13	189	15.0	405	247	239	8.0	89	366	453	53	322	49.8	43.5	237
22 9	216.1	352.9	359.9	3.3	158.4	174.9	364	174.1	13	189	15.1	404	249	241	8.0	148	367	453	54	321	49.8	44.0	238
22 30	215.6	352.9	360.0	3.3	157.8	175.1	364	174.4	181	189	14.9	404	247	239	7.9	173	367	453	53	322	49.8	44.0	239
22 31	215.6	352.9	360.0	3.1	160.5	175.2	364	174.7	181	189	14.8	404	244	237	7.6	210	366	453	53	321	49.8	44.7	240
22 31	215.6	352.9	360.1	3.2	160.0	175.1	364	174.2	181	189	14.9	404	247	240	7.8	221	366	453	54	321	49.8	44.1	241
22 31	215.6	352.9	360.0	3.2	158.7	175.1	364	174.7	181	189	14.9	405	248	240	7.7	256	366	452	54	321	49.8	44.4	242
22 31	215.5	352.9	360.1	3.5	156.8	174.6	364	174.1	181	189	14.9	406	247	239	8.1	261	367	454	52	321	49.8	43.6	243
22 32	215.5	353.0	360.1	3.7	157.8	175.1	364	174.3	181	189	14.9	406	248	240	8.7	253	368	454	52	321	49.8	42.6	244
22 32	215.5	353.0	360.1	3.3	158.8	175.5	364	174.7	181	189	14.8	404	249	241	8.0	209	366	453	52	322	49.8	43.5	245
22 32	215.5	353.0	360.2	3.2	159.9	175.3	364	174.1	181	190	14.9	406	247	240	7.8	219	367	455	54	322	49.8	44.2	246
22 32	215.5	352.9	360.1	3.2	160.3	175.7	364	174.7	181	189	14.9	405	249	242	7.9	168	367	453	54	322	49.9	44.0	247
22 32	215.5	353.0	360.1	3.3	157.5	175.2	364	174.5	181	189	14.9	404	248	240	7.9	148	365	453	53	321	49.8	44.0	248
22 32	215.5	352.9	360.0	3.5	156.7	174.8	364	174.1	181	189	14.6	405	247	239	8.1	153	367	453	52	322	49.7	43.2	249
22 59	216.3	352.6	360.3	3.2	159.5	176.3	364	175.5	181	189	15.0	404	243	235	7.7	443	366	453	54	321	49.7	45.6	250
23 29	216.9	351.7	359.6	3.0	159.0	175.7	364	174.9	12	189	15.2	404	250	243	7.6	515	366	453	56	321	49.7	45.5	251
0 0	216.8	351.7	359.6	3.0	158.7	175.9	364	175.2	12	190	15.3	404	253	245	7.7	445	366	453	57	321	49.6	45.2	252

3.31.82

Table B-4. Unprocessed Data - Performance Test Results, Part 13 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	Mi	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
0 30	216.9	352.5	360.1	3.1	159.1	175.9	365	175.1	13	190	15.1	404	251	244	7.8	263	367	453	56	321	49.7	44.2	253
1 0	217.0	351.8	359.9	3.0	159.7	176.3	364	175.5	13	190	15.2	404	250	242	7.7	403	367	453	56	321	49.7	45.5	254
1 30	217.0	351.8	359.7	3.0	159.0	176.1	364	175.1	13	190	15.3	404	253	245	7.8	353	366	453	59	321	50.0	45.0	255
2 0	217.6	352.6	359.8	3.1	157.9	175.9	364	175.0	12	190	15.4	405	257	249	7.9	285	367	453	60	321	49.9	44.0	256
2 30	217.9	352.0	359.2	3.2	156.9	175.2	364	174.6	13	190	15.4	404	261	253	8.1	256	367	453	63	321	49.8	43.6	257
3 0	217.7	352.0	359.9	3.0	158.0	175.9	364	175.0	13	190	15.4	404	262	254	7.9	259	367	453	61	321	49.9	43.8	258
3 30	218.0	352.1	360.0	3.1	157.8	175.8	364	175.1	12	190	15.5	405	259	251	8.0	244	367	453	61	321	49.9	44.2	259
4 0	218.1	352.0	359.6	3.1	156.9	175.6	364	174.8	13	190	15.4	404	264	256	8.1	-12	367	453	63	321	49.8	43.2	260
4 30	217.5	353.4	361.0	3.2	158.4	176.1	364	175.4	13	190	15.4	404	255	247	7.9	-12	367	453	60	321	50.1	43.7	261
5 0	218.1	351.8	359.5	3.2	155.6	175.2	364	174.3	11	190	15.5	404	267	258	8.4	-11	367	453	64	321	49.8	42.8	262
5 30	218.2	355.1	361.1	3.6	156.9	175.7	365	174.9	13	190	15.6	404	266	258	8.5	-11	368	453	64	321	50.2	40.8	263
6 0	218.8	352.0	358.9	3.3	154.7	174.6	364	173.7	13	190	15.7	404	278	269	8.7	-10	368	453	69	321	49.9	41.0	264
6 30	218.8	351.9	359.0	3.3	155.1	174.8	364	173.8	14	190	15.7	405	275	266	8.6	-12	368	454	67	321	50.0	41.5	265
7 0	218.9	351.7	358.2	3.4	151.7	173.4	364	172.5	13	190	15.7	404	294	285	9.3	-15	368	453	72	321	50.0	38.8	266
7 30	219.4	351.3	357.3	3.4	150.4	172.9	363	171.9	13	190	15.8	405	298	289	9.3	-13	369	453	76	321	49.9	38.7	267
8 0	219.8	351.2	357.2	3.4	150.7	172.6	363	171.8	11	190	15.9	404	302	293	9.4	-14	369	453	76	321	50.0	38.5	268
8 30	220.4	351.5	355.8	3.6	146.8	171.5	363	170.7	13	190	16.1	404	318	308	9.9	-15	368	453	85	321	49.9	36.7	269
11 37	219.9	350.4	359.6	2.7	159.2	176.6	364	176.0	13	190	15.8	334	255	247	7.5	482	367	435	61	254	50.0	38.6	273
12 7	219.5	356.0	362.1	3.4	159.6	176.9	365	176.2	14	190	15.8	335	246	239	7.6	483	366	434	62	254	49.9	36.4	274
12 37	219.9	355.8	361.2	3.5	157.1	175.9	365	175.4	13	189	15.9	334	262	253	8.2	108	368	434	65	254	49.7	34.2	275
13 7	220.9	355.5	360.2	3.7	154.0	175.1	364	174.5	12	189	16.0	334	271	263	8.6	17	368	435	70	254	49.9	33.2	276
13 37	221.0	355.4	359.7	3.7	153.6	174.7	364	174.1	12	189	16.1	334	277	268	8.7	1	368	434	72	254	49.7	32.6	277
14 7	221.0	352.4	356.4	3.6	147.7	172.3	363	171.7	13	189	16.1	334	308	298	9.3	1	368	435	82	254	49.9	30.8	278
14 37	219.9	350.8	359.1	2.9	157.0	176.0	364	175.5	15	190	15.8	314	261	253	7.8	3	368	407	63	223	49.9	33.2	279
17 47	216.2	353.0	352.0	0.0	167.7	174.2	247	179.8	184	192	14.8	280	304	304	0.0	7	367	445	17	220	49.8	33.5	4
17 47	216.3	353.0	352.0	0.0	168.1	174.6	247	179.1	184	192	14.6	279	304	304	0.0	13	367	446	17	220	49.8	33.3	5
17 47	216.3	353.0	352.0	0.0	167.7	174.3	247	179.7	184	192	14.8	280	304	304	0.0	2	368	446	17	220	50.0	33.4	6
17 47	216.3	353.0	352.1	0.0	167.9	174.2	247	178.8	184	192	14.8	280	304	304	0.0	-7	367	447	17	219	49.7	33.4	7
17 47	216.3	353.0	352.1	0.0	168.0	174.0	247	178.6	183	192	14.8	280	302	302	0.0	14	367	446	17	220	49.8	33.7	8
17 47	216.2	353.0	352.1	0.0	167.1	174.1	247	178.7	183	192	14.6	279	303	303	0.0	-3	367	446	18	220	49.6	33.3	9
17 47	216.3	353.0	352.0	0.0	167.2	173.8	247	179.4	183	192	14.8	280	303	303	0.0	-3	367	446	18	220	50.0	33.6	10
17 47	216.3	353.0	352.1	0.0	167.6	174.1	246	179.1	183	192	14.6	279	305	305	0.0	5	367	447	17	220	49.8	33.1	11
17 47	216.3	353.0	352.1	0.0	167.7	174.1	246	179.0	183	192	14.8	279	305	305	0.0	13	367	446	17	220	49.8	33.4	12
17 47	216.2	353.0	352.1	0.0	167.9	174.3	246	179.2	184	192	14.6	280	305	305	0.0	-5	367	448	17	220	49.8	33.1	13
17 49	216.2	353.1	352.1	0.0	166.8	173.6	252	178.3	184	192	14.8	279	307	307	0.0	7	367	447	18	220	49.8	33.1	14
17 49	216.1	353.0	352.1	0.0	167.5	173.7	252	178.7	183	192	14.8	279	307	307	0.0	2	367	446	17	220	50.0	33.1	15
17 49	216.1	353.1	352.2	0.0	166.8	173.7	252	179.1	183	192	14.8	279	305	305	0.0	2	367	446	18	220	49.7	33.3	16
17 49	216.0	353.1	352.2	0.0	167.1	173.8	252	179.1	183	192	14.6	279	305	305	0.0	6	368	446	18	220	49.7	33.0	17
17 49	216.0	353.1	352.1	0.0	167.1	173.6	253	178.9	183	192	14.8	279	305	305	0.0	0	367	445	19	220	49.7	33.2	18

4.1.82

Table B-4. Unprocessed Data - Performance Test Results, Part 14 of 15

TDS=360000 ppm,Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
17 49	216.0	353.1	352.2	0.0	167.2	173.7	253	178.4	183	192	14.8	280	306	306	0.0	-5	367	448	18	220	49.7	33.2	19
17 49	216.1	353.0	352.2	0.0	166.9	173.5	252	178.4	183	192	14.8	278	306	306	0.0	8	368	446	18	220	49.7	33.2	20
17 49	216.1	353.0	352.2	0.0	167.0	173.5	252	178.8	183	192	14.6	281	307	307	0.0	3	367	446	18	220	49.8	32.9	21
17 50	216.1	353.0	352.2	0.0	166.9	173.5	252	178.3	183	192	14.8	279	307	307	0.0	3	368	446	18	220	49.8	33.2	22
17 50	216.2	353.0	352.2	0.0	166.7	173.5	251	178.2	183	192	14.8	280	307	307	0.0	0	368	447	18	220	49.8	33.1	23
17 53	216.5	353.2	352.3	0.0	166.3	172.8	251	177.8	182	191	14.8	278	303	303	0.0	6	366	446	17	220	49.8	33.5	24
17 53	216.4	353.1	352.3	0.0	166.0	172.5	251	177.8	182	191	14.9	279	303	303	0.0	-9	366	446	18	220	50.0	33.8	25
17 53	216.3	353.2	352.3	0.0	166.7	173.0	251	178.3	182	191	14.6	279	304	304	0.0	27	367	445	17	220	49.8	33.1	26
17 53	216.3	353.1	352.3	0.0	166.6	173.2	250	177.8	182	191	14.8	280	303	303	0.0	-5	367	446	17	220	50.0	33.5	27
17 53	216.3	353.1	352.3	0.0	166.6	172.8	250	178.0	182	191	14.8	279	303	303	0.0	-0	367	447	17	220	49.7	33.5	28
17 54	216.4	353.0	352.3	0.0	166.7	173.1	250	177.8	182	191	14.6	279	303	303	0.0	11	366	446	17	220	49.8	33.3	29
17 54	216.4	353.0	352.3	0.0	166.1	172.7	250	177.3	182	191	14.6	280	303	303	0.0	5	367	448	18	220	49.9	33.3	30
17 54	216.4	353.0	352.3	0.0	166.7	173.3	250	177.4	182	191	14.6	280	303	303	0.0	-10	366	446	16	220	50.2	33.4	31
17 54	216.3	353.0	352.3	0.0	167.1	173.2	250	177.4	182	191	14.8	279	301	301	0.0	7	366	447	16	220	49.8	33.7	32
17 54	216.3	352.9	352.3	0.0	166.6	173.1	250	177.8	182	191	14.8	279	299	299	0.0	-5	367	446	16	220	49.8	34.1	33
18 29	216.2	352.7	351.9	0.0	167.7	173.7	222	176.5	182	191	14.8	283	288	288	0.0	5	366	446	14	219	50.0	35.3	34
18 29	216.4	352.8	352.0	0.0	167.7	173.5	222	176.8	183	191	14.8	276	287	287	0.0	-14	366	448	14	219	49.9	35.4	35
18 29	216.4	352.7	351.9	0.0	167.2	173.2	222	175.8	182	191	14.8	277	286	286	0.0	17	366	446	14	219	49.9	35.5	36
18 29	216.4	352.7	352.0	0.0	167.0	173.6	222	176.4	182	191	14.8	277	287	287	0.0	11	367	446	15	219	50.1	35.5	37
18 30	216.3	352.6	352.0	0.0	167.9	173.8	222	176.4	183	191	14.8	277	287	287	0.0	-10	365	446	14	219	50.0	35.5	38
18 30	216.3	352.6	352.0	0.0	167.0	173.5	222	176.3	182	191	14.6	277	287	287	0.0	23	366	446	14	219	49.9	35.2	39
18 30	216.4	352.6	351.9	0.0	167.7	173.5	222	176.0	182	191	14.6	276	287	287	0.0	-3	366	447	14	218	50.0	35.1	40
18 30	216.2	352.6	351.9	0.0	167.8	173.7	222	176.3	182	191	14.6	276	287	287	0.0	7	366	447	14	219	49.8	35.2	41
18 30	216.3	352.5	351.9	0.0	167.4	173.2	222	176.2	182	191	14.6	277	288	288	0.0	16	366	447	14	219	50.0	35.2	42
18 30	216.3	352.5	351.9	0.0	168.1	174.2	222	176.1	182	191	14.6	277	287	287	0.0	2	366	448	14	218	49.9	35.2	43
18 36	216.7	353.7	352.3	0.0	163.8	170.6	222	175.2	181	190	14.8	341	323	323	0.0	-8	367	447	21	263	50.0	36.4	44
18 36	216.6	353.7	352.5	0.0	163.4	170.6	222	174.7	181	190	14.8	336	323	323	0.0	1	366	446	22	263	50.0	36.5	45
18	216.6	353.7	352.5	0.0	163.1	170.1	222	174.3	181	190	14.9	335	324	324	0.0	1	365	447	21	263	49.9	36.7	46
18 36	216.6	353.7	352.5	0.0	163.2	170.1	222	174.8	181	190	14.8	335	324	324	0.0	13	365	447	22	263	49.9	36.4	47
18 36	216.6	353.7	352.5	0.0	163.1	170.1	222	174.5	180	190	14.9	335	324	324	0.0	-8	365	446	22	263	50.0	36.6	48
18 36	216.6	353.6	352.6	0.0	163.0	170.0	222	174.2	180	190	14.8	338	325	325	0.0	19	365	446	22	263	49.9	36	49
18 36	216.6	353.7	352.6	0.0	162.8	169.8	222	175.3	181	190	14.9	335	325	325	0.0	14	366	446	23	263	49.8	36.5	50
18 36	216.7	353.6	352.6	0.0	162.8	170.0	222	175.3	181	190	14.9	335	327	327	0.0	-9	366	447	22	264	50.0	36.5	51
18 36	216.6	353.7	352.6	0.0	163.1	170.1	222	174.7	181	190	14.8	335	328	328	0.0	12	366	446	22	263	50.0	36.0	52
18 36	216.7	353.6	352.6	0.0	163.2	170.1	222	174.7	180	191	14.9	335	327	327	0.0	10	366	447	22	263	50.0	36.3	53
18 37	216.5	[illegible]	352.3	0.0	161.8	169.0	222	174.0	180	190	14.9	332	330	330	0.0	15	366	446	23	262	49.9	36.1	54
18 38	216.5	353.3	352.3	0.0	161.5	168.7	222	173.5	180	189	14.8	336	331	331	0.0	9	366	446	24	263	49.9	35.9	55
18 38	216.5	353.2	352.3	0.0	161.7	168.6	222	173.7	180	190	14.8	335	330	330	0.0	-4	366	446	23	263	49.9	35.9	56
18 38	216.5	353.3	352.3	0.0	161.7	168.7	222	173.7	180	189	14.8	335	331	331	0.0	14	366	447	23	264	49.9	35.9	57

Table B-4. Unprocessed Data - Performance Test Results, Part 15 of 15

TDS=360000 ppm;Inert gasses=38.0 wt% of vapor

TIME	T2	Tf	T1	Q1	P1	Pf	Tv	Pv	Ps	Pw	P2	I	M1	Mf	Mv	Ls	Ts	V	Trt%	kW	freq	eff%	File
18 38	216.5	353.2	352.3	0.0	161.6	168.7	222	173.3	180	189	14.8	335	331	331	0.0	8	366	447	24	263	49.9	35.8	58
18 38	216.[illegible]	353.2	352.3	0.0	161.6	168.3	222	173.3	179	189	14.8	336	330	330	0.0	-2	366	448	23	263	49.9	35.9	59
18 38	216.5	353.2	352.3	0.0	161.3	168.[illegible]	222	173.8	179	189	14.8	335	331	331	0.0	5	365	446	24	263	49.8	35.8	60
18 38	216.5	353.2	352.3	0.0	161.5	168.6	222	173.5	179	190	14.6	335	332	332	0.0	-0	365	446	24	263	49.9	35.5	61
18 38	216.6	353.2	352.3	0.0	161.5	168.3	222	173.3	179	190	14.6	335	333	333	0.0	-7	366	447	24	263	49.9	35.4	62
18 38	216.5	353.2	352.2	0.0	161.5	168.5	222	173.0	179	189	14.8	336	334	334	0.0	-2	367	447	24	263	50.0	35.5	63
19 13	214.8	353.8	352.7	0.0	164.7	171.7	222	179.5	184	191	14.6	336	352	352	0.0	5	366	447	25	263	49.7	33.2	64
19 13	214.7	353.8	352.6	0.0	165.1	171.6	222	179.6	184	192	14.6	337	366	366	0.0	24	365	448	24	263	49.9	31.9	65
19 13	214.9	353.7	352.6	0.0	165.1	171.3	222	179.5	184	191	14.6	335	356	356	0.0	3	365	446	24	264	49.9	32.9	66
19 13	214.8	353.7	352.6	0.0	164.5	171.3	222	179.8	184	191	14.6	335	354	354	0.0	46	365	446	26	264	49.7	33.1	67
19 13	214.9	353.7	352.6	0.0	164.5	171.6	222	179.3	184	191	14.6	336	359	359	0.0	5	365	447	24	263	49.8	32.5	68
19 14	[illegible]5.0	353.6	352.6	0.0	165.2	171.6	222	179.4	18[illegible]	191	14.6	335	365	365	0.0	5	364	447	23	263	49.9	32.1	69
19 14	[illegible]5.1	353.6	352.6	0.0	165.0	171.3	222	179.1	184	191	14.6	336	355	355	0.0	15	365	446	24	264	49.8	33.0	70
19 14	215.0	353.6	352.6	0.0	163.9	171.0	222	179.2	184	191	14[illegible]	[illegible]	357	357	0.0	29	365	448	26	264	49.8	32.8	71
19 14	214.9	353.7	352.5	0.0	164.0	171.5	222	179.0	184	191	14.[illegible]	[illegible]5	359	359	0.0	19	364	446	24	263	49.9	32.6	72
19 14	215.0	353.7	352.5	0.0	165.1	171.0	222	178.9	183	191	14.6	335	[illegible]55	355	0.0	8	364	446	24	264	49.8	33.0	73

Table B-5. Cesano Test Results (Ref. B, Table 4)

POINT (files)	KW	I	P_1	P_2	Q1 (inlet steam quality)	eff.%	thr.%	KWs	η*
1(17÷27)	128	168	171,3	14,86	0,0	30,7	7	167	9,79
2(29÷51)	139	220	170,7	14,70	0,0	30,85	8	178	9,61
3(52÷72)	138,5	219	166,5	14,6	1,6	38,3	22	178	11,95
4(73÷83)	106,4	168	165,9	14,7	0,0	27,6	7	145	9,25
5(85÷108)	201	317	165,9	14,8	2,0	39,9	31	241	11,11
6(109÷112)	201	317	161,0	14,8	2,1	38,3	36	241	10,61
7(135÷161)	216,5	282,6	128,4	14,7	2,7	45,5	47	257	11,91
8(4÷19)	433	531	160,2	15,9	3,0	45,4	80	477	9,89
9(24÷47)	441	657	157,7	15,9	3,1	45,1	86	486	9,73
10(49÷68)	408	604	160,1	15,8	2,8	44,7	77	452	9,93
11(84÷86)	302	454	160,0	16,7	2,7	36,5	75	344	8,79
12(89÷107)	185	267	174,9	14,9	0,0	36,2	8	225	10,39
13(109÷118)	173	230	176,1	14,8	0,0	35,5	7	213	10,43
14(119÷139)	150	216	177,8	14,9	0,0	35,9	6	189	11,00
15(140÷149)	190	267	174,8	14,9	0,0	37,2	7	230	10,60
16(150÷178)	190	267	177,6	14,9	0,0	36,2	7	230	10,35
17(199÷222)	196	243	151,0	14,8	0,0	33,5	16	236	9,21
18(234÷250)	321	405	158,1	14,9	3,3	44,4	53	363	10,71

Table B-6. Data Correlation Functions (Ref. 1, pp. 7-22 to 7-24)

The data correlation functions are as follows:

$$f_W = -21.36 + 10.25 \ln kWs - 0.072[abs(kWs - 520)]^{0.6}$$

$$g_P = 1 - 0.019\left(\frac{P1}{P2} - 15\right)$$

$$g_Q = 1 - 0.54\left(\frac{Q1 - 41}{100}\right)^3 + 0.0004(Q1 - 28)$$

where

kWs = shaft output power;

P1 = inlet pressure;

P2 = outlet pressure;

and

Q1 = inlet quality

so that experimental efficiency $\eta = f_W g_P g_Q$, within the validity limits of the correlation functions.

APPENDIX C

NEW ZEALAND/MWD

Figure C-1	Broadlands Well BR 19 Output Test (Ref. C, Appendix A)
Figure C-2	Broadlands Well BR 19 Casing and Geological Information (Ref. C, Appendix A)
Figure C-3 through Figure C-19	Tabulated Variables, Performance Data, and Graphs (Ref. C, Figs. B.1 through B.17)
Table C-1	Broadlands Well BR 19 Fluid Chemistry (Ref. C, Appendix A)
Table C-2	Variables Logged by the Data Acquisition System (Ref. C, Appendix D)
Table C-3	Transducers (Ref. C, Appendix D)
Table C-4	Test Chronology (Ref. C, Appendix E)
Table C-5	Performance Calculation Procedure (Ref. C, Appendix C)
Table C-6	Variable List (Ref. C, Appendix B)
Table C-7	Performance Test Results (Ref. C, Appendix B)
Table C-8	Endurance Test Record (Ref. C, Appendix B)

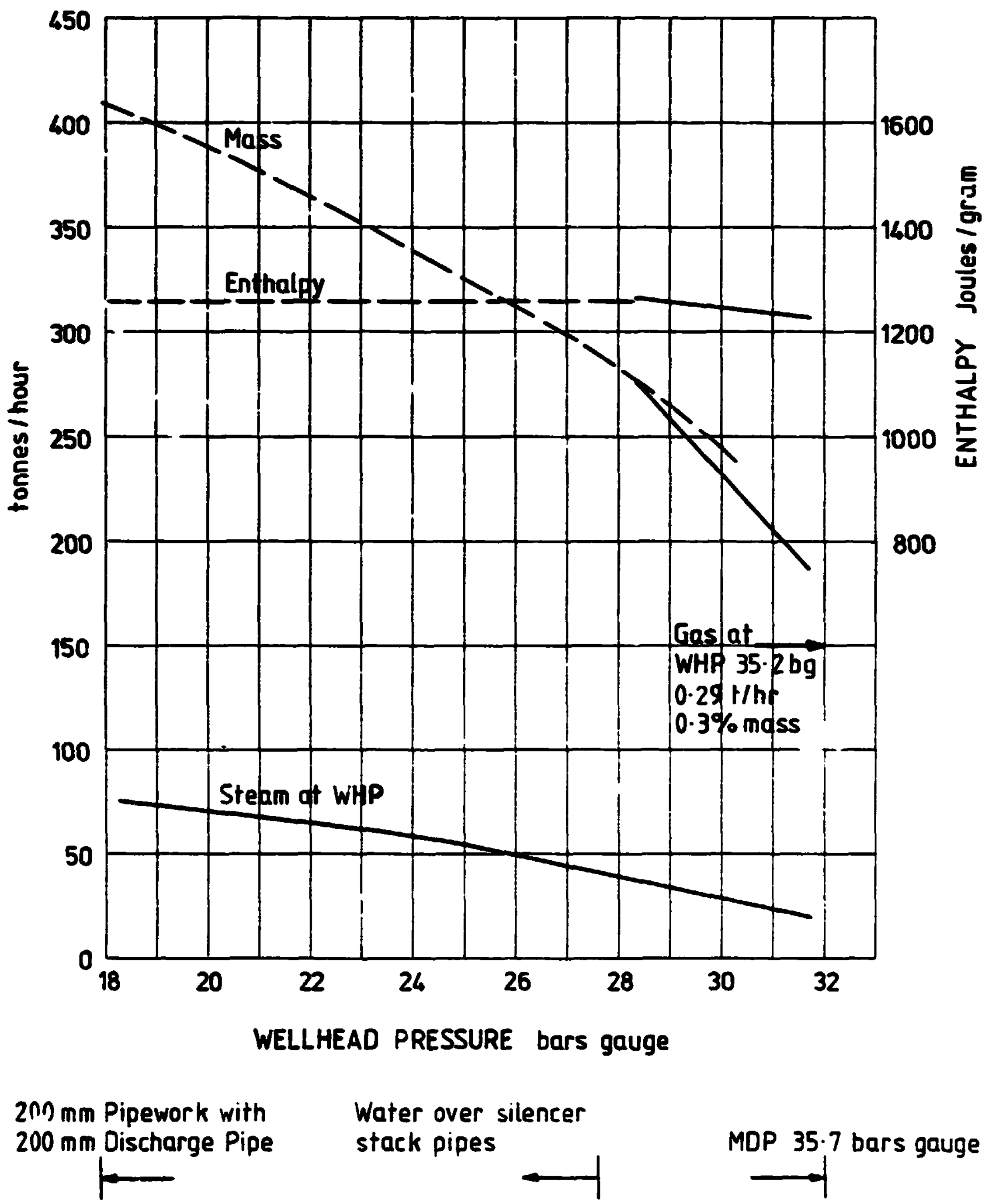

Figure C-1. Broadlands Well BR 19 Output Test (Ref. C, Appendix A)

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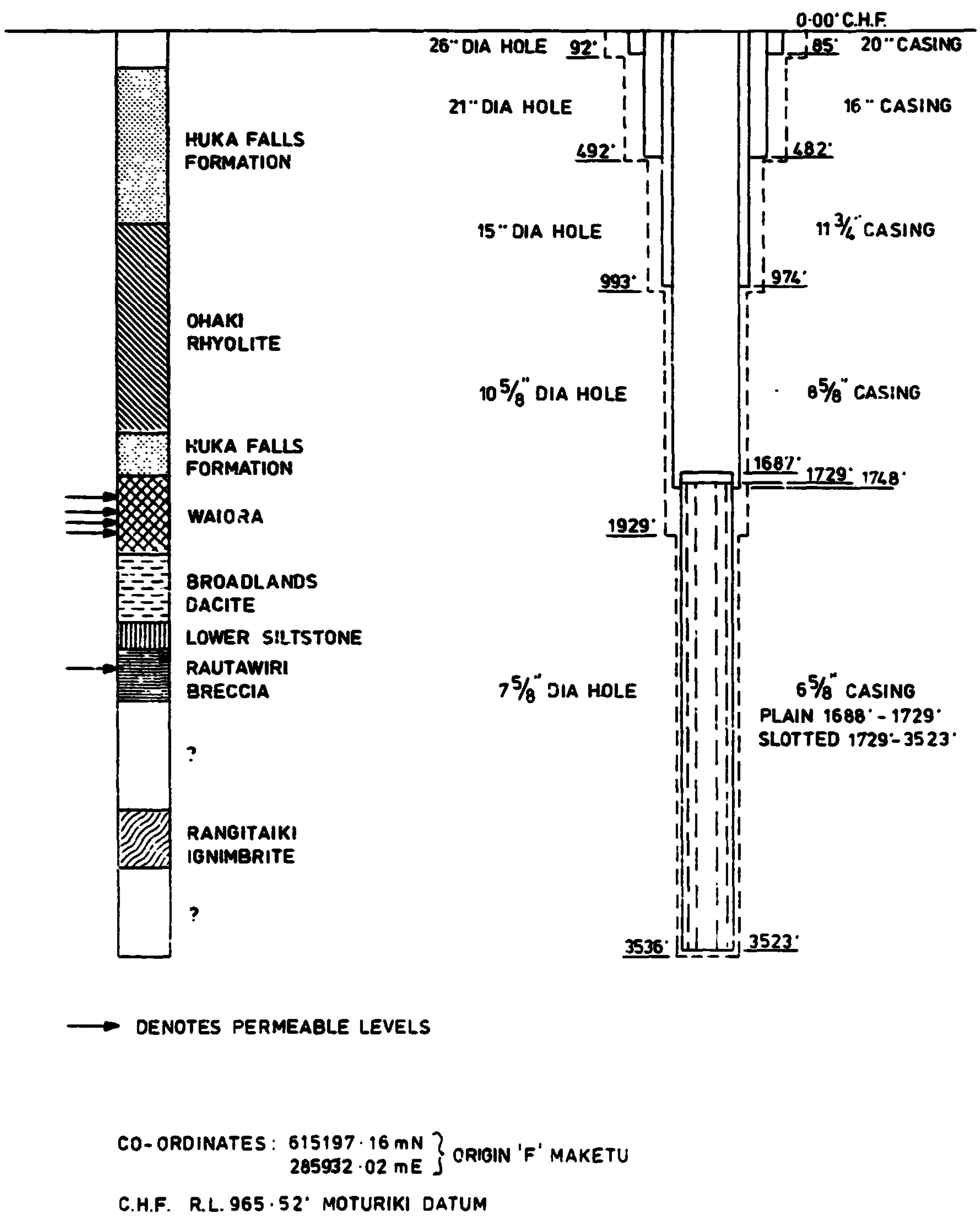

Figure C-2. Broadlands Well BR 19 Casing and Geothermal Information (Ref. C, Appendix A)

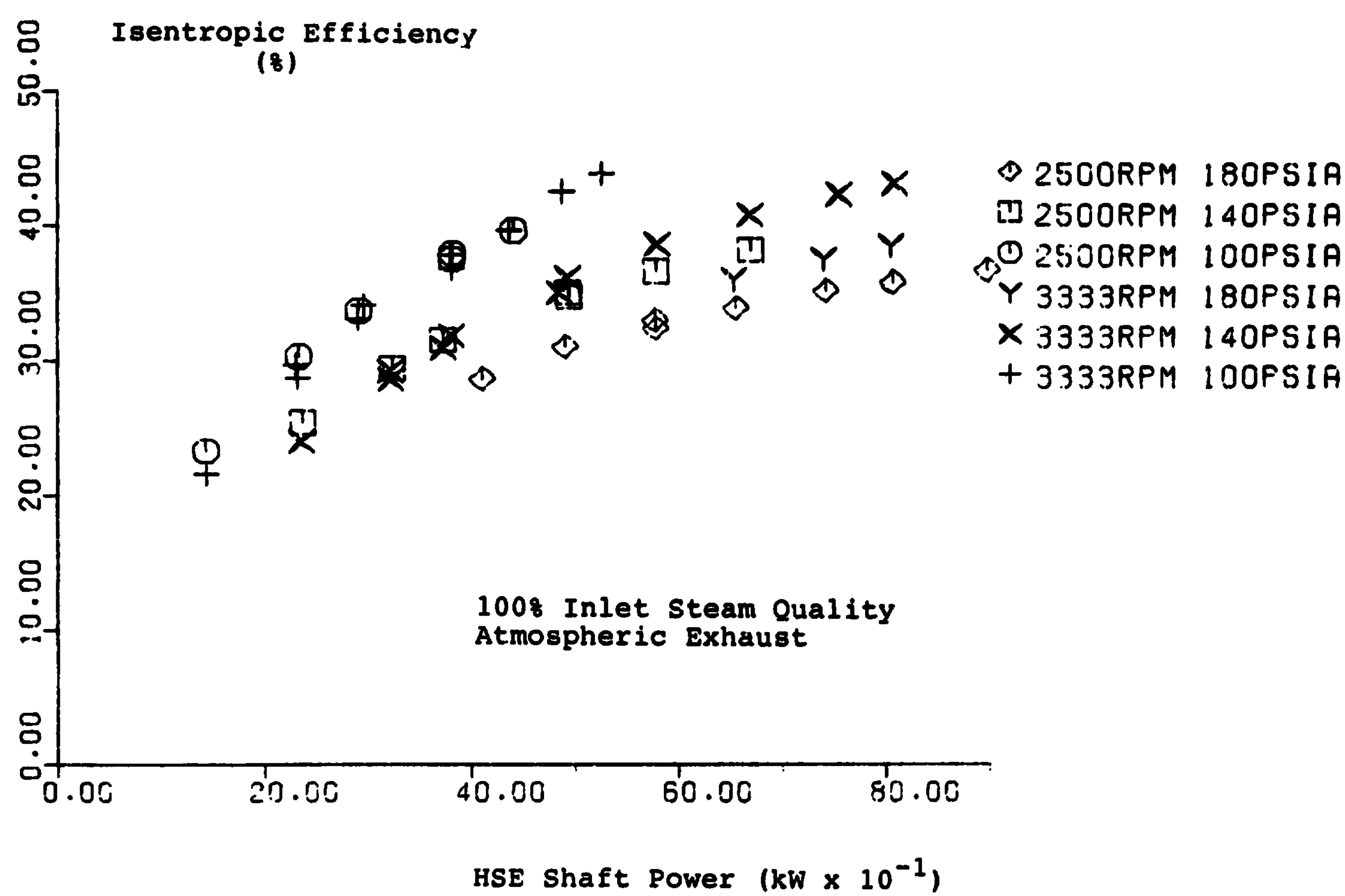

Figure C-3. Helical Screw Expander Data--100% Inlet Steam Quality (Ref. C, Fig. B.1)

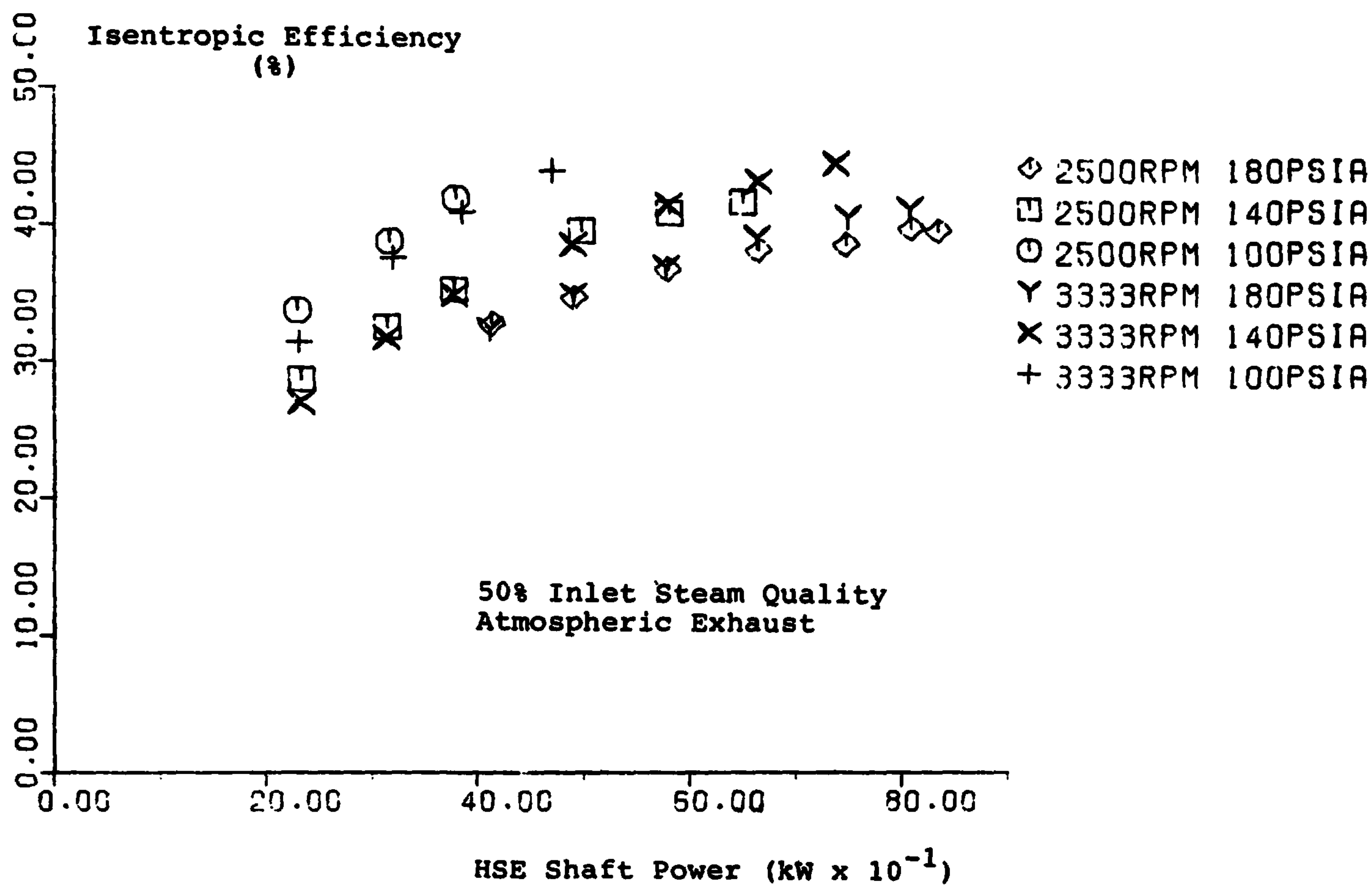

Figure C-4. Helical Screw Expander Data--50% Inlet Steam Quality (Ref. C, Fig. B.2)

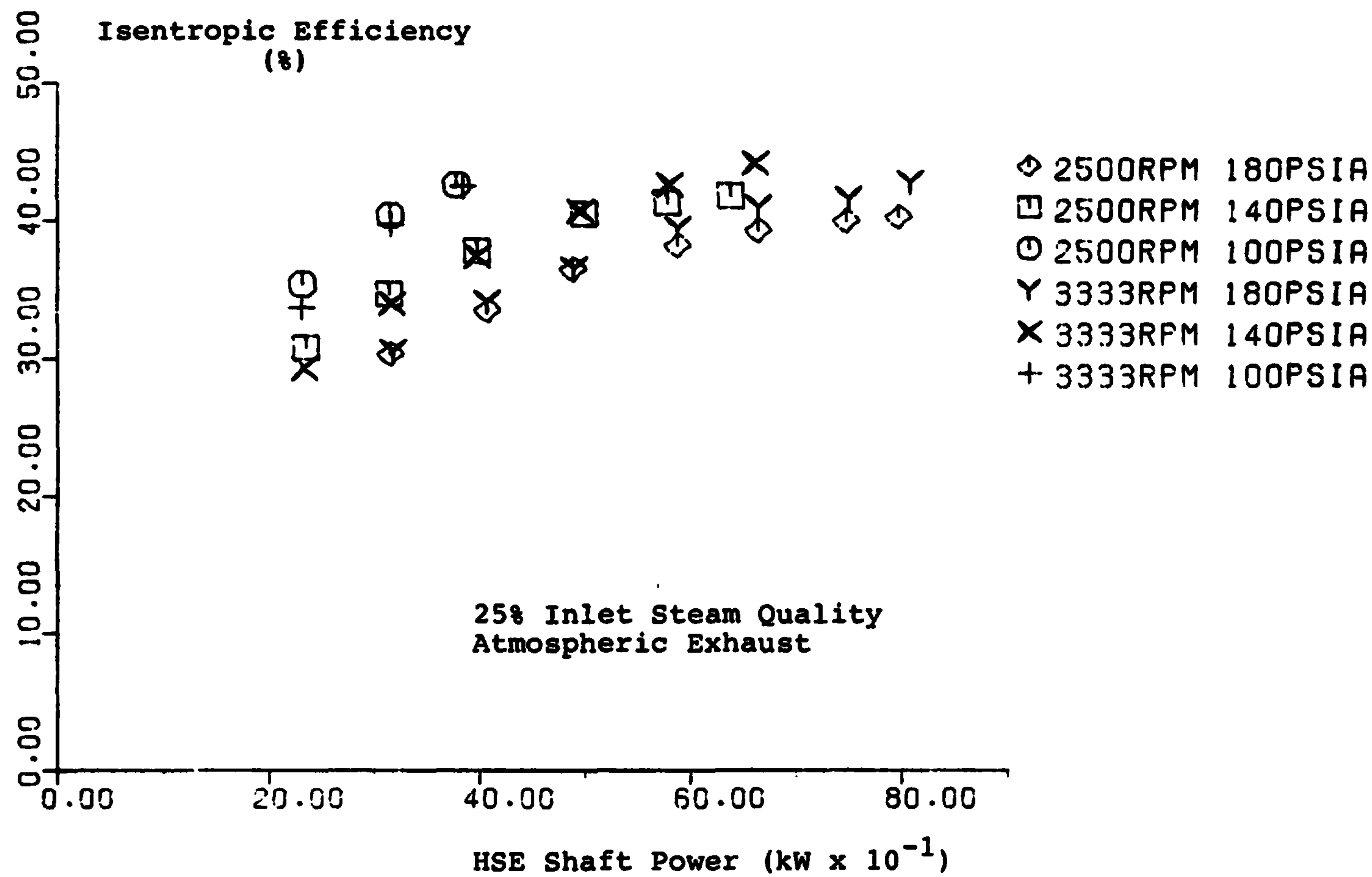

Figure C-5. Helical Screw Expander Data--25% Inlet Steam Quality (Ref. C, Fig. B.3)

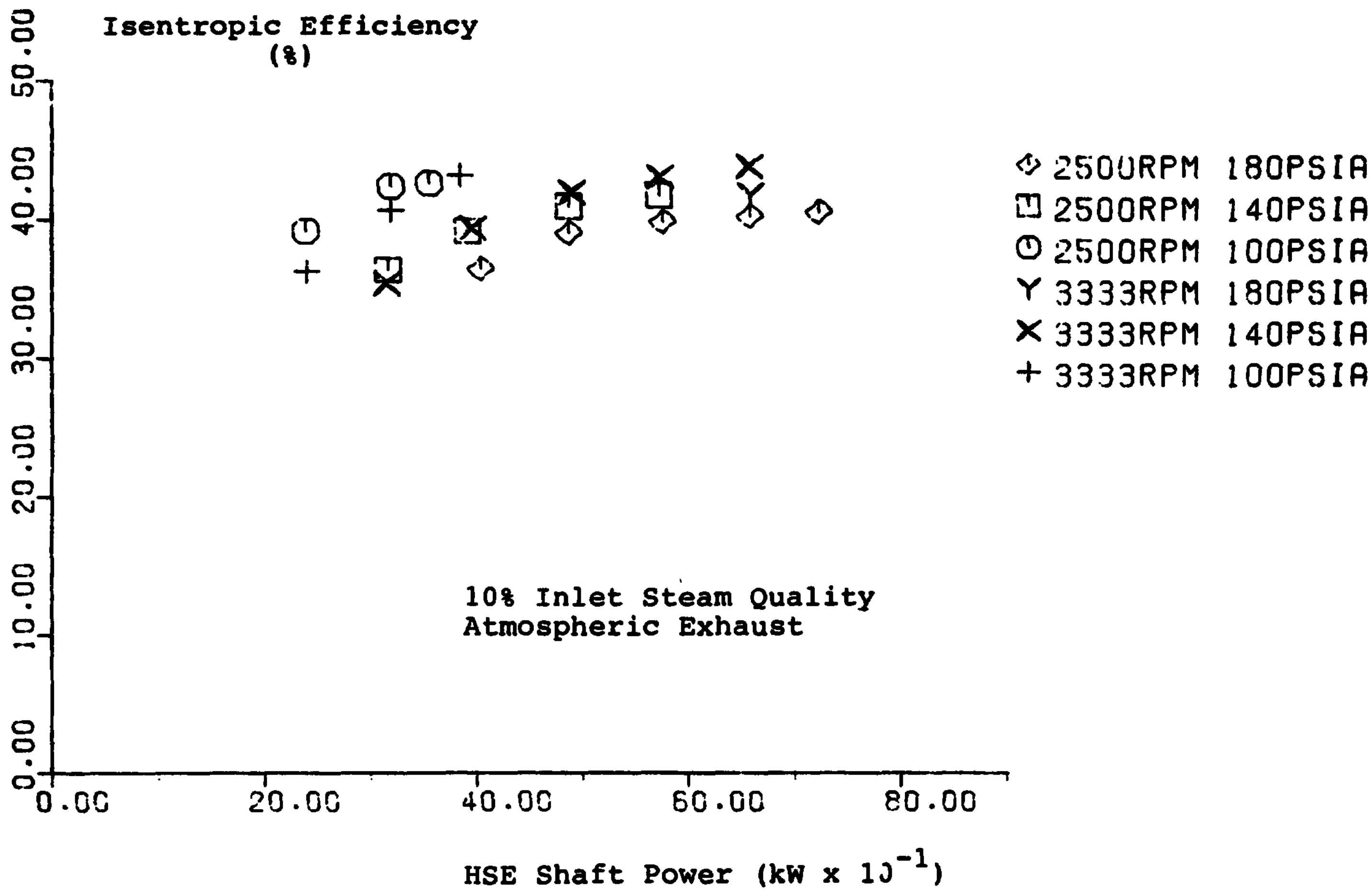

Figure C-6. Helical Screw Expander Data--10% Inlet Steam Quality (Ref. C, Fig. B.4)

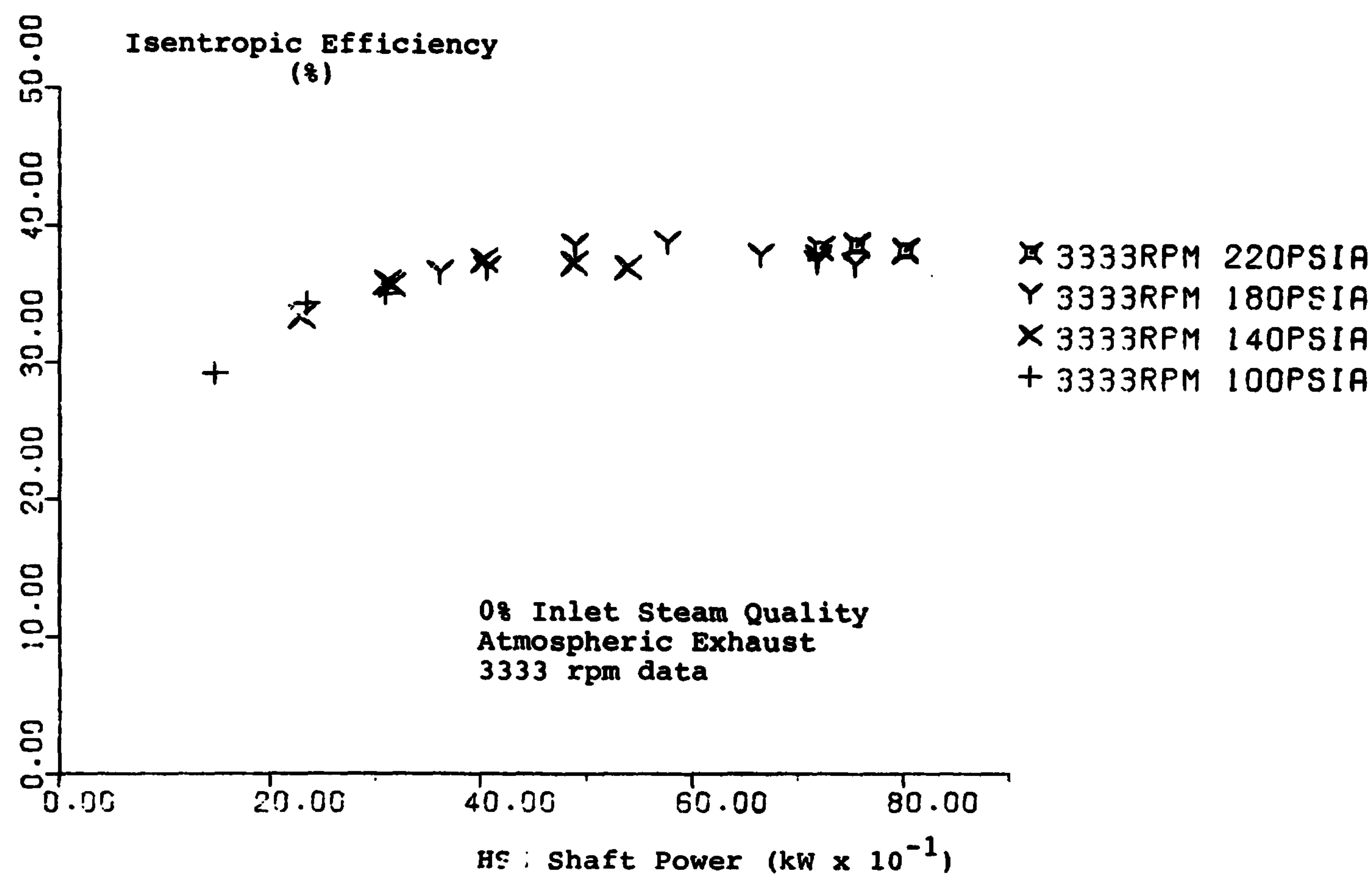

Figure C-7. Helical Screw Expander Data--0% Inlet Steam Quality at 3333 rpm (Ref. C, Fig. B.5)

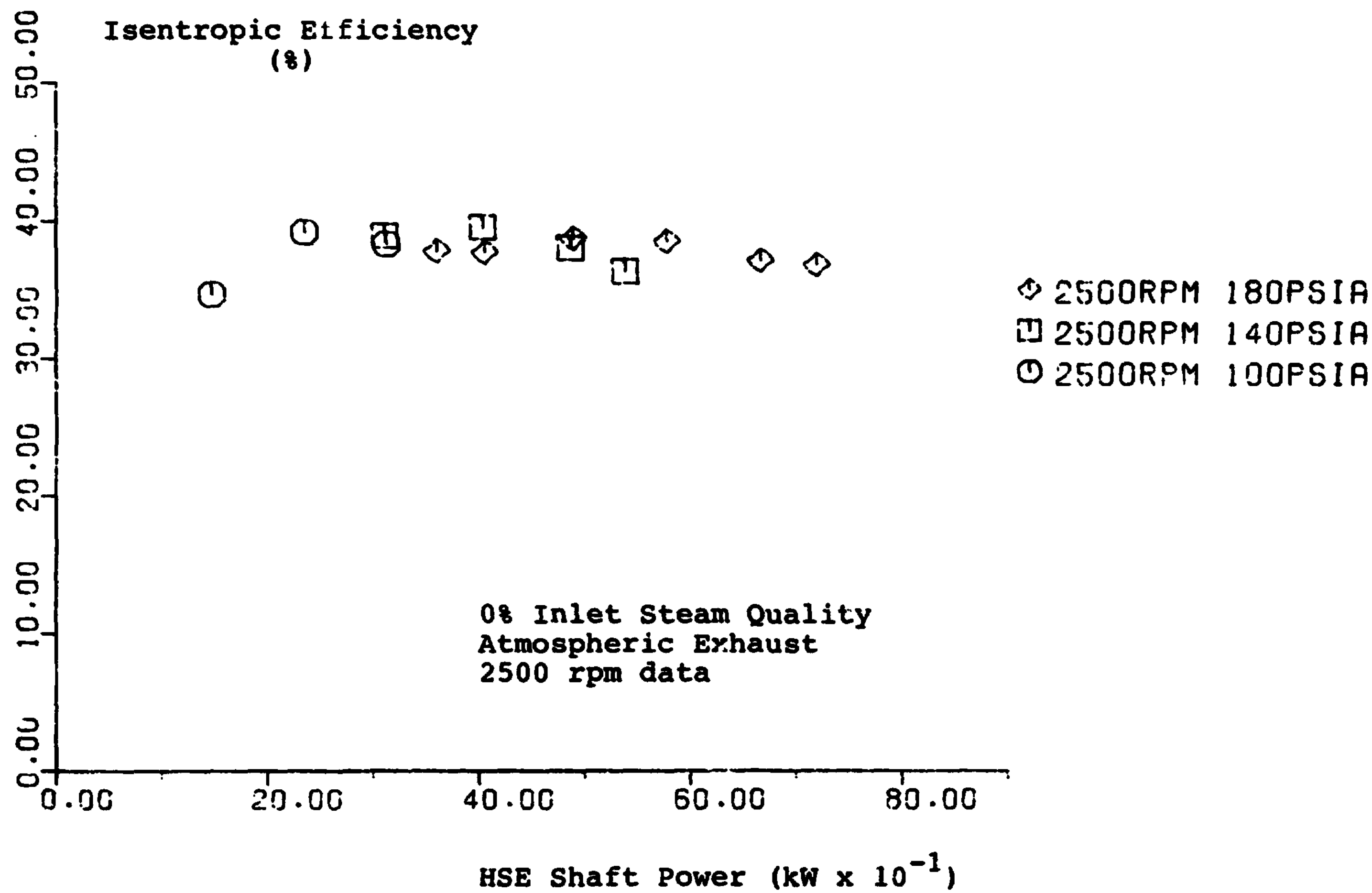

Figure C-8. Helical Screw Expander Data--0% Inlet Steam Quality at 2500 rpm (Ref. C, Fig. B.6)

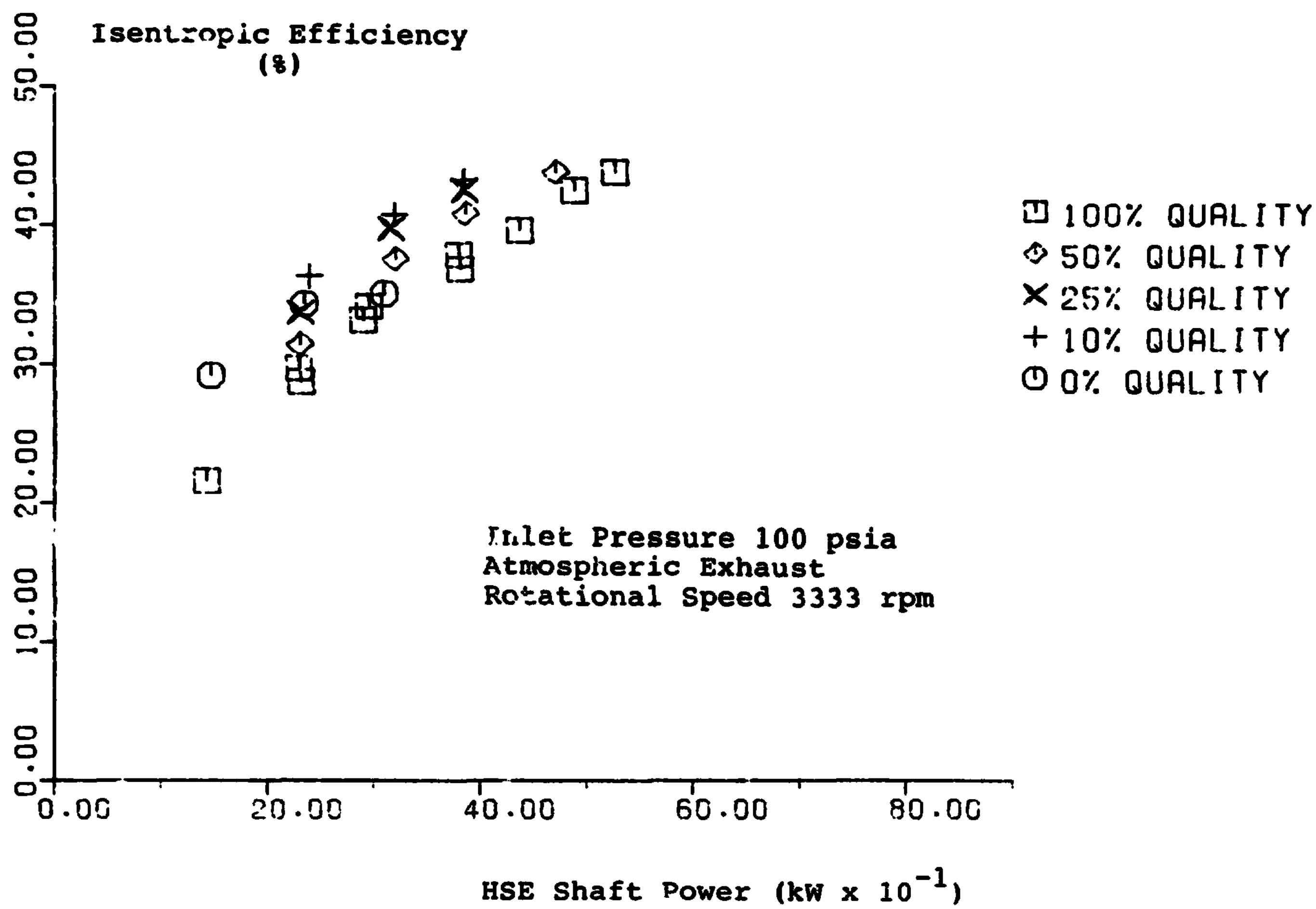

Figure C-9. Helical Screw Expander Data--100 psia Inlet Pressure at 3333 rpm (Ref. C, Fig. B.7)

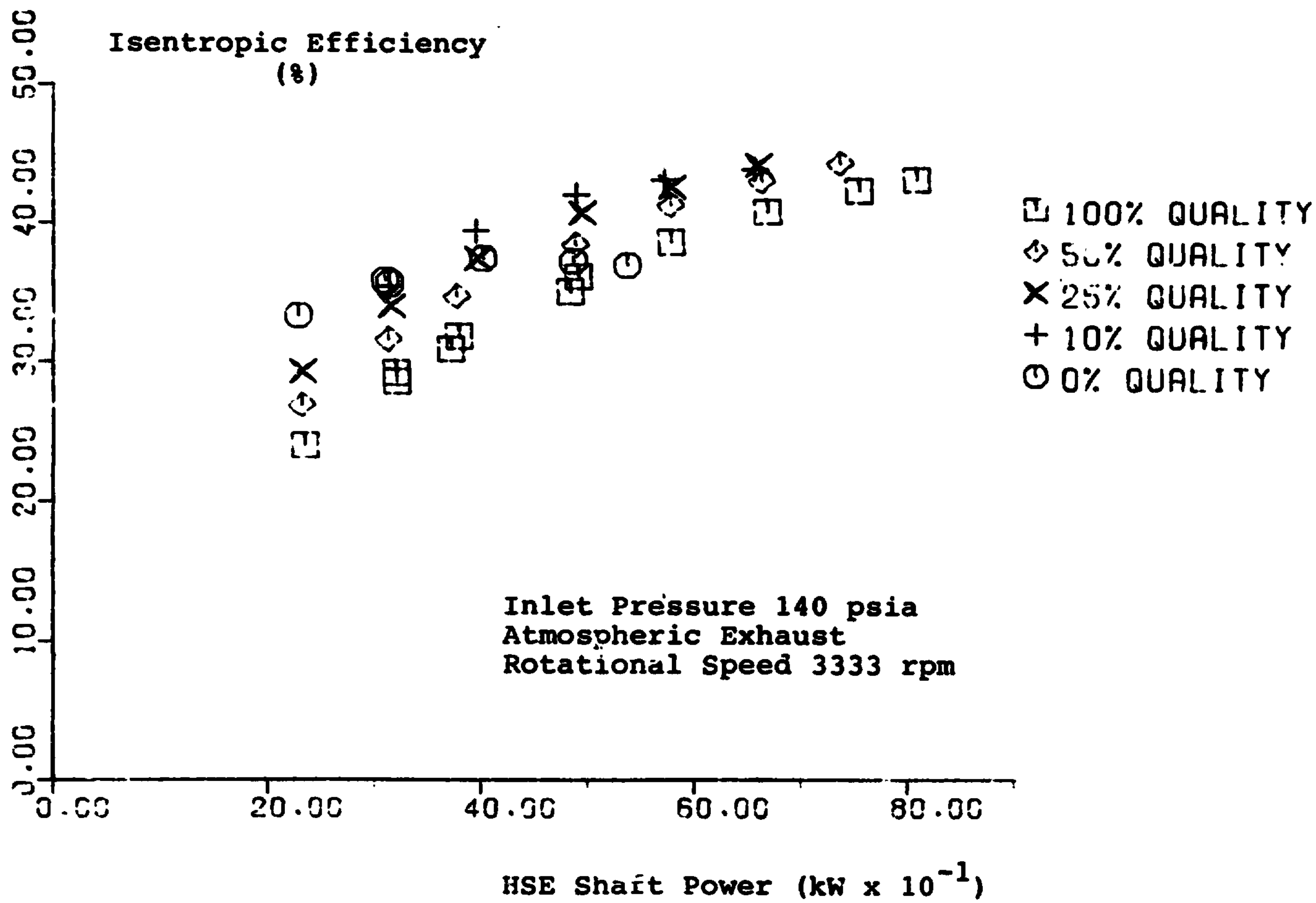

Figure C-10. Helical Screw Expander Data--140 psia Inlet Pressure at 3333 rpm (Ref. C, Fig. B.8)

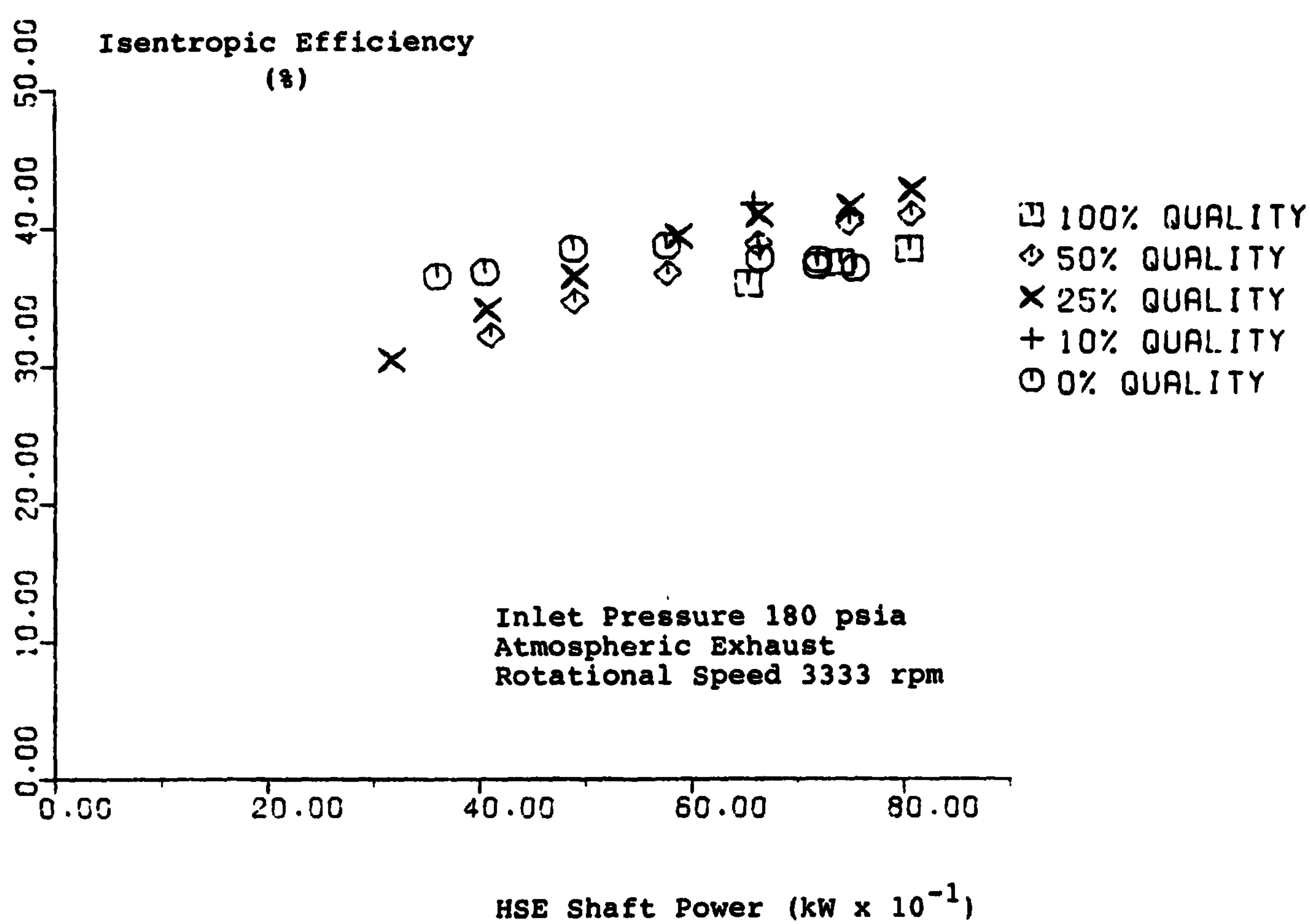

Figure C-11. Helical Screw Expander Data--180 psia Inlet Pressure at 3333 rpm (Ref. C, Fig. B.9)

C-3

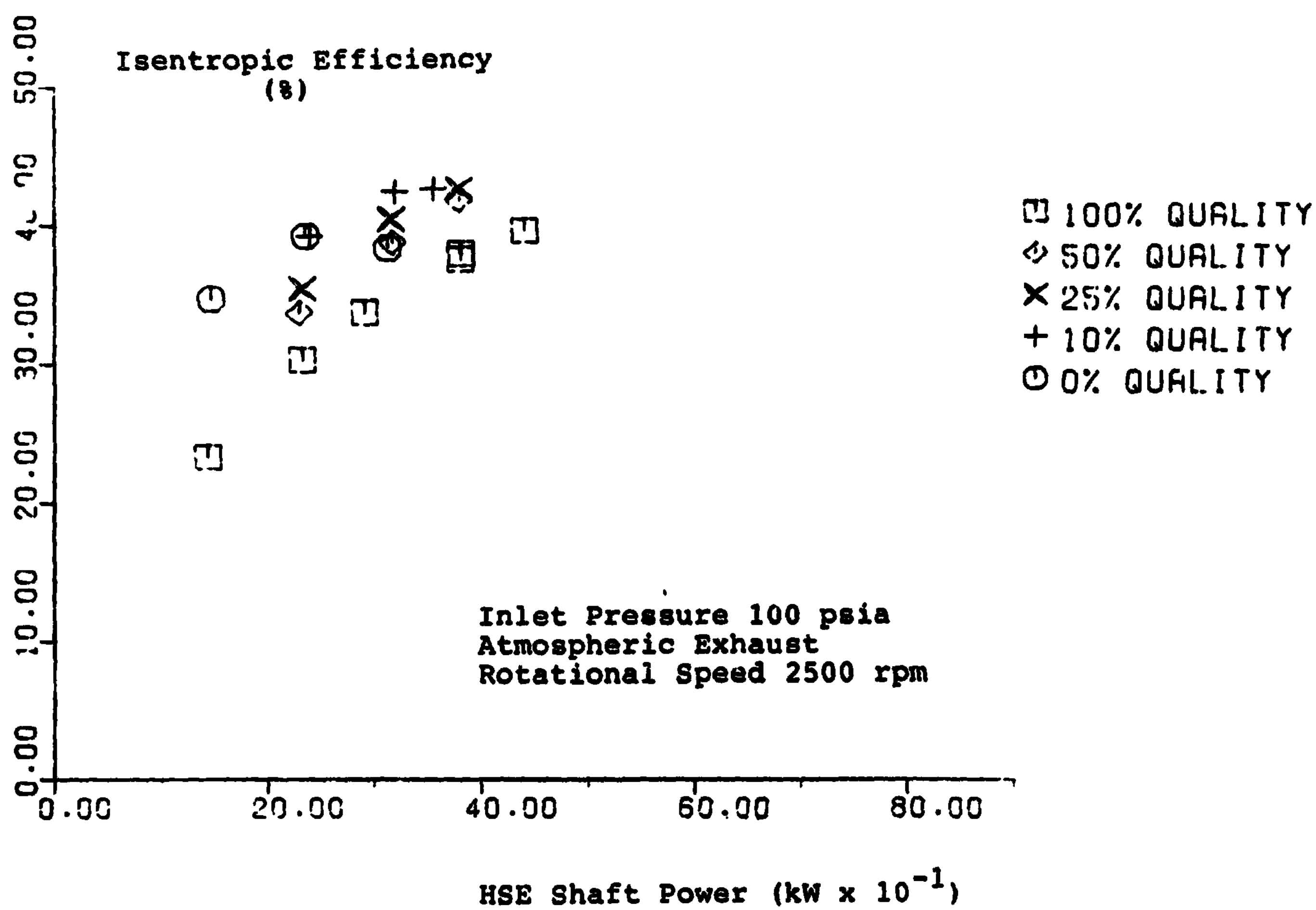

Figure C-12. Helical Screw Expander Data--100 psia Inlet Pressure at 2500 rpm (Ref. C, Fig. B.10)

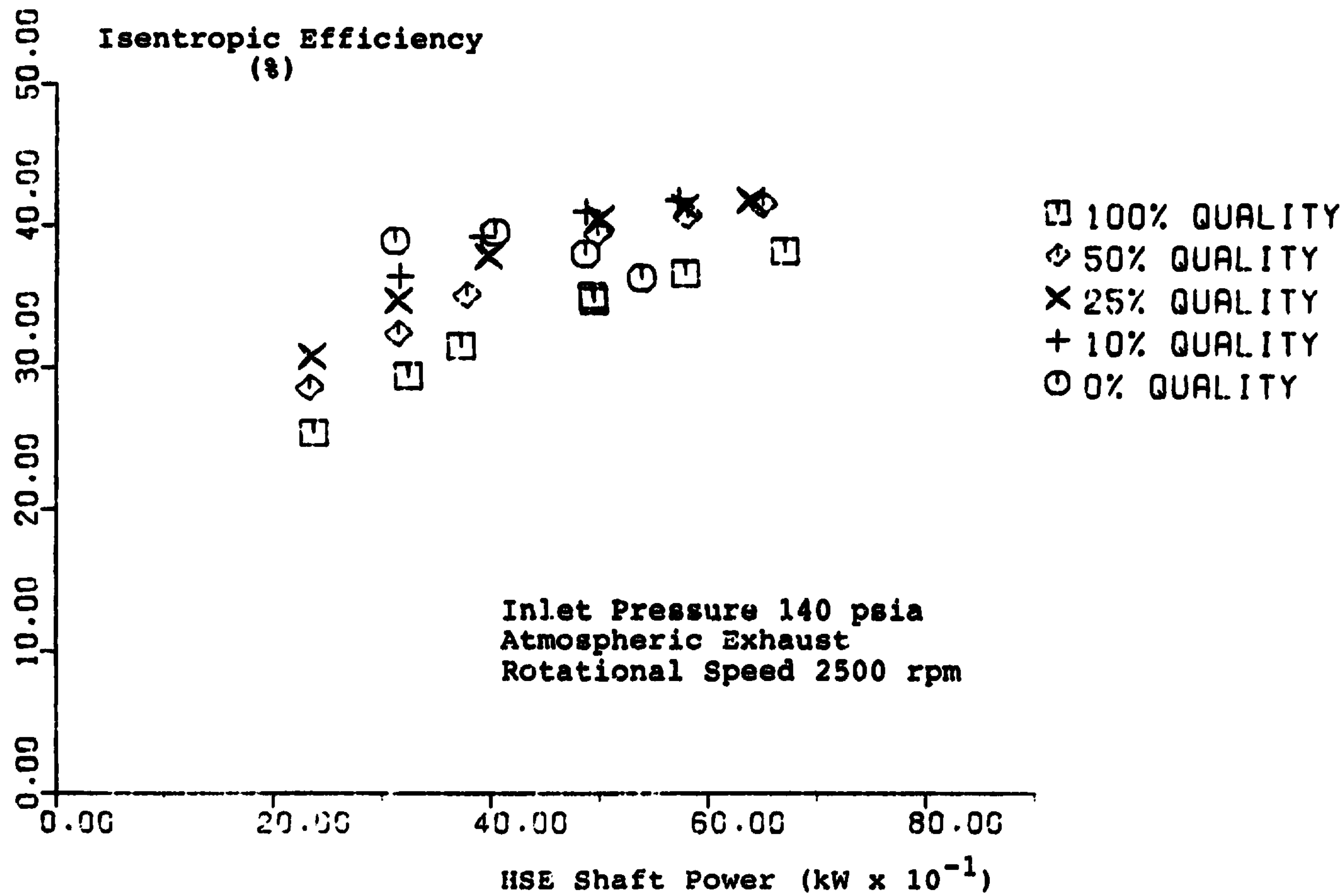

Figure C-13. Helical Screw Expander Data--140 psia Inlet Pressure at 2500 rpm (Ref. C, Fig. B.11)

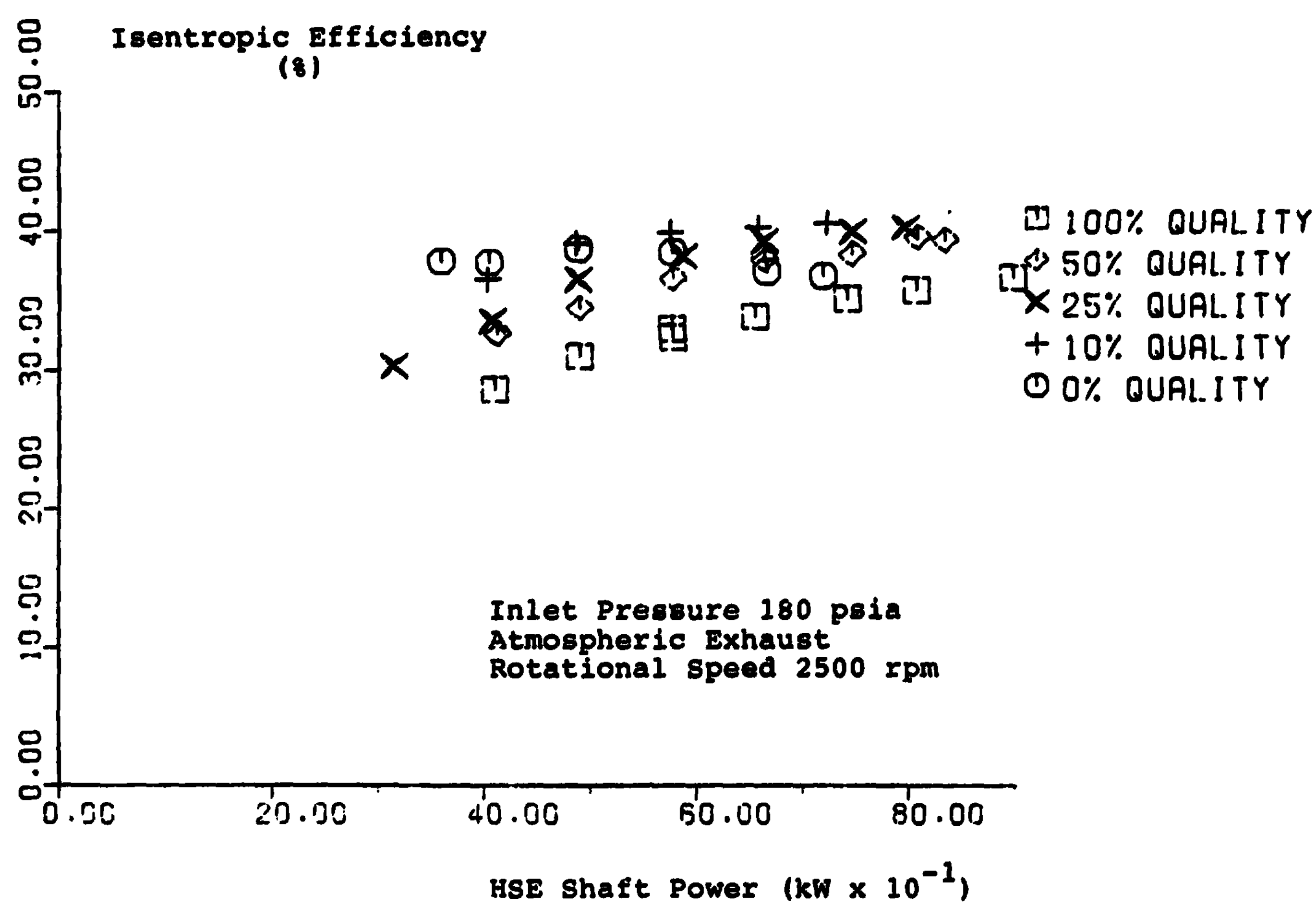

Figure C-14. Helical Screw Expander Data--180 psia Inlet Pressure at 2500 rpm (Ref. C, Fig. B.12)

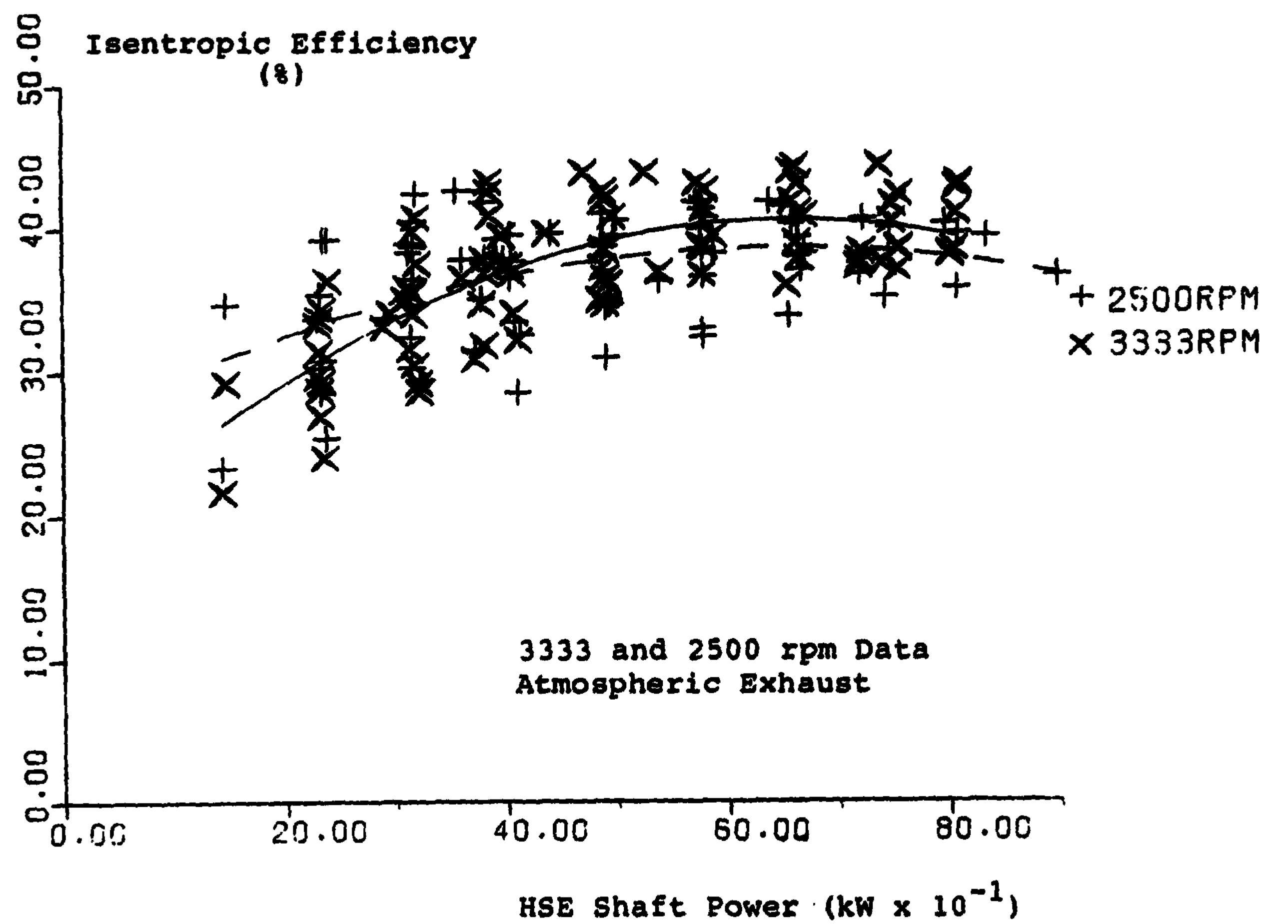

Figure C-15. Helical Screw Expander--3333 and 2500 rpm Performance Data (Ref. C, Fig. B.13)

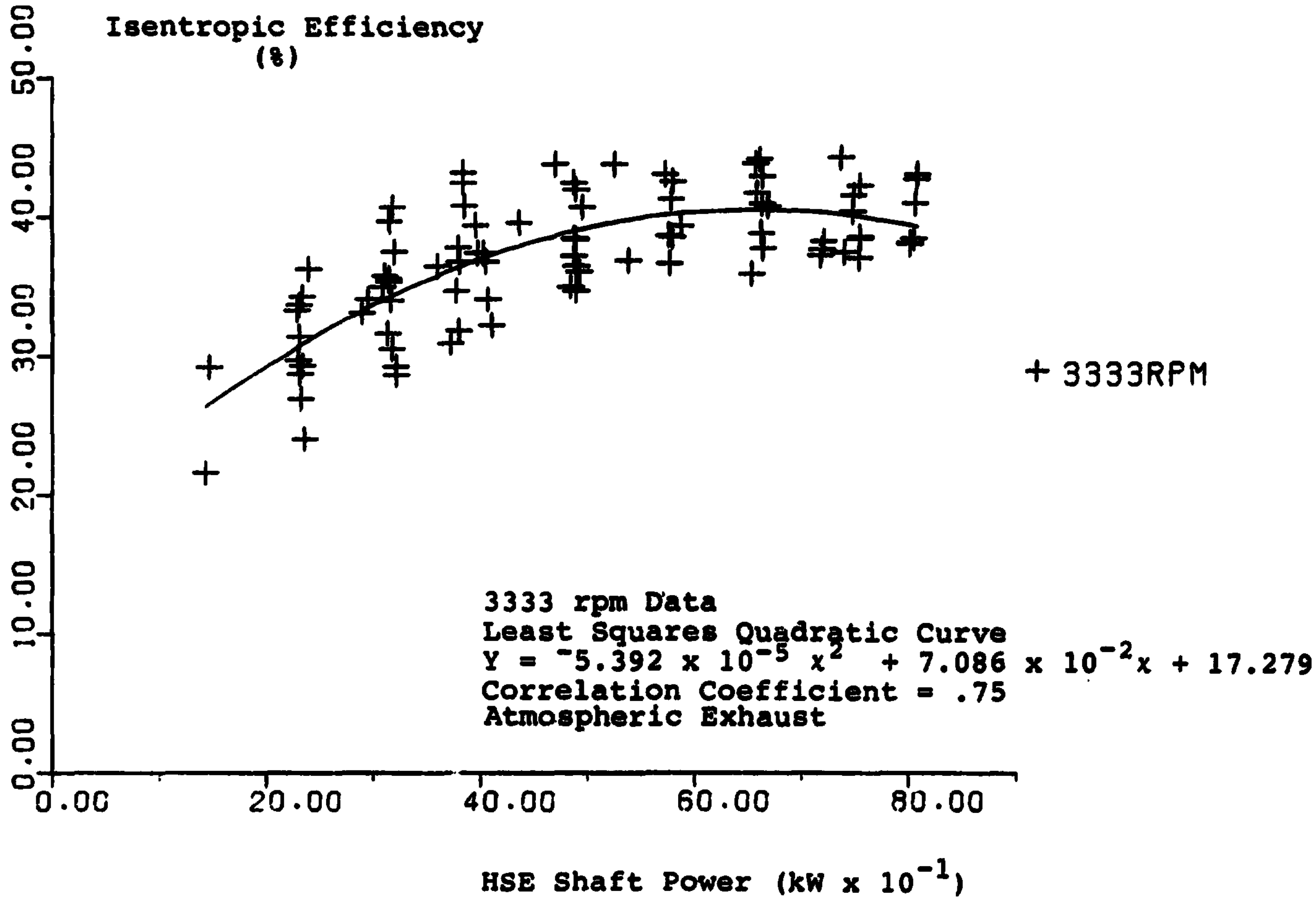

Figure C-16. Helical Screw Exp der--3333 rpm Performance Data (Ref. C, Fig. B.14)

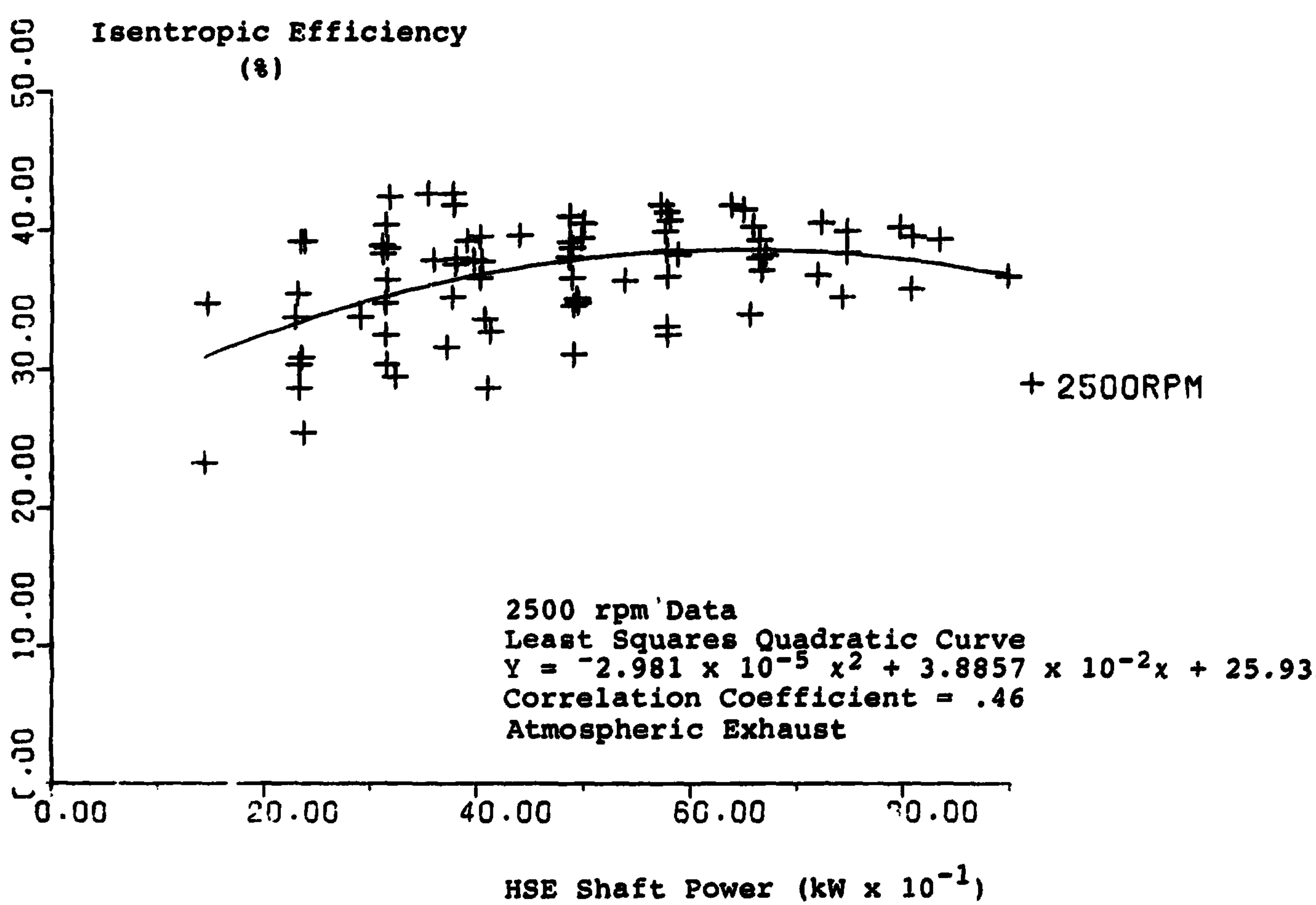

Figure C-17. Helical Screw Expander--2500 rpm Performance Data (Ref. C, Fig. B.15)

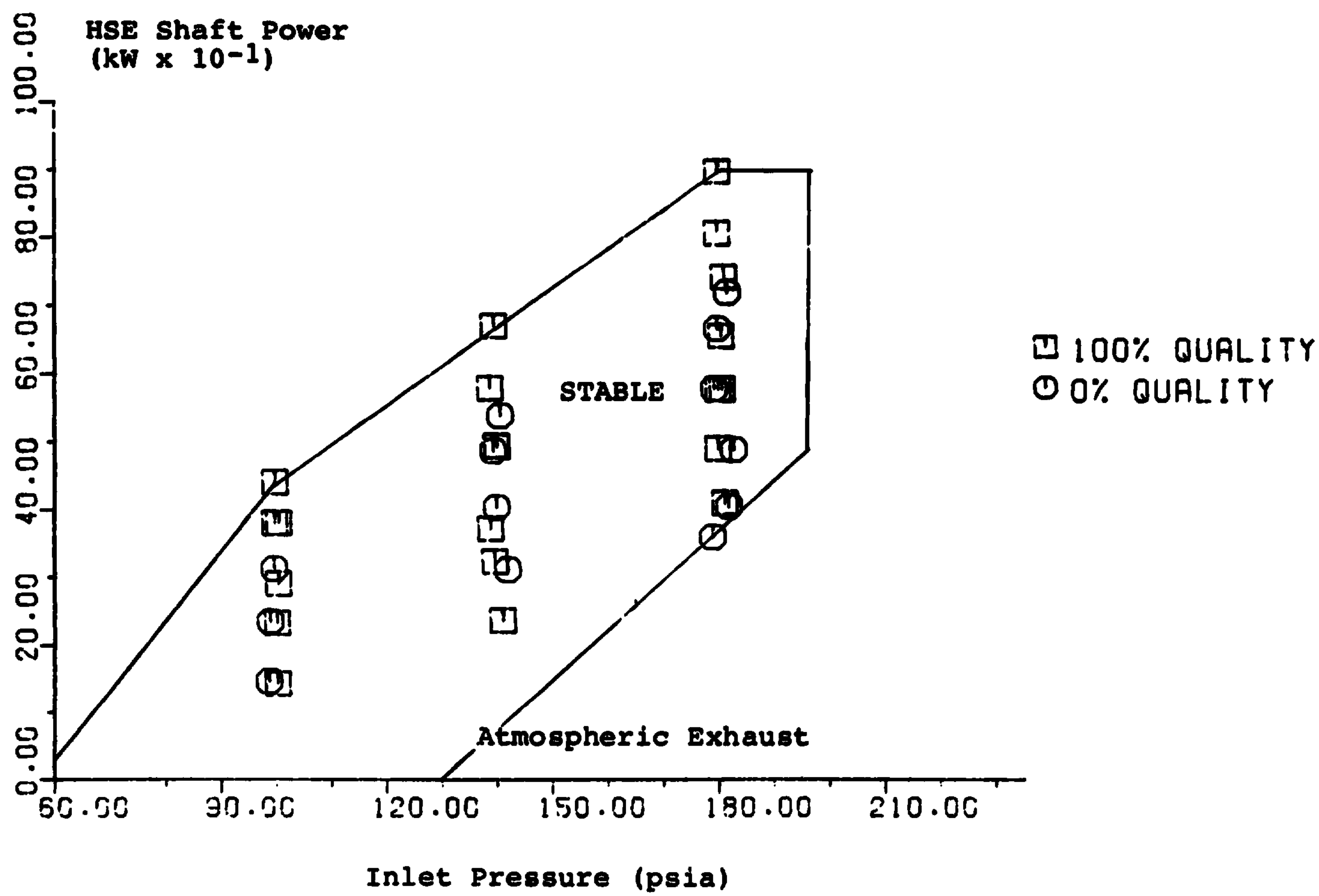

Figure C-18. Helical Screw Expander--2500 rpm Stability Envelope (Ref. C, Fig. B.16)

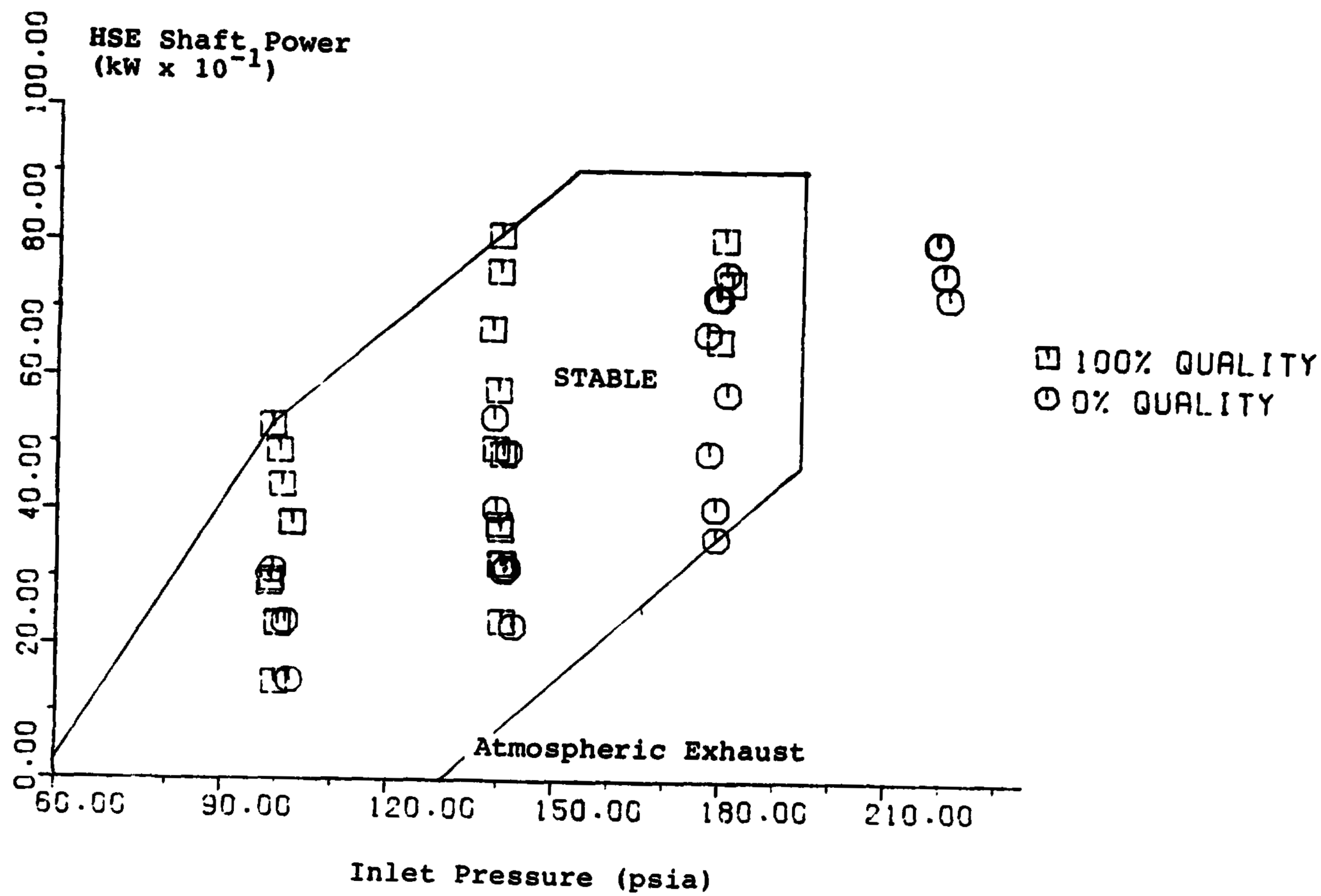

Figure C-19. Helical Screw Expander--3333 rpm Stability Envelope (Ref. C, Fig. B.17)

Table C-1. Broadlands Well BR 19 Fluid Chemistry--Samples Taken During the HSE Test Program (Ref. C, Appendix A)

WATER SAMPLES

Date Collected	24/10/82	21/10/82	3/3/83	3/3/83	3/3/83
Type *	EWB	BWB	WHS	WEB	EWB
W.H.P. (Bar g)	27	27	35	35	35
Sep. Pressure (Bar)	11	11	12.8	12.8	12.8
Collection Pressure (Bar g)	1	1	1	1	1
pH	8.91	8.64	7.46	7.39	-
Li	11.99	12.60	10.30	9.88	11.74
Na	971	1025	824	773	945
K	191	202	167	157	188
Ca	2.4	2.3	1.2	1.0	2.1
Mg	0.01	0.03	0.04	0.01	0.01
Cl	1658	1747	1341	1287	1528
SO_4	7	8	7	-	-
B	44.1	48.8	38.1	-	-
SiO_2	805	850	644	607	709
HCO_3	75	134	205	195	-
H_2S	-	-	14.7	15.6	-

* EWB = HSE Exhaust Weir Box
BWB = Bypass Weir Box
WHS = Wellhead Separator
WEB = Webre Separator (Sampling)

STEAM SAMPLES

Date Collected	21/10/82	3/3/83	3/3/83	28/4/83
W.H.P. (B)	27	35	35	33
Sampling Point Pressure	-	12.7	12.8	12.6
Sampling Pressure	-	12.6	12.8	12.0
CO_2 (mmoles/100 moles)	802	862	902	1108
H_2S (mmoles/100 moles)	16.2	17.8	17.9	19.7
NH_3 (mg/lit)	-	-	-	48.6

Table C-2. Variables Logged by the Data Acquisition System (Ref. C, Appendix D), Part 1 of 2

VARIABLE	SYMBOL	UNITS	VECTOR LOCATION
Wellhead Pressure	Pw	psia	1
Steam Orifice Upstream Pressure	Pv	psia	8
Steam Orifice Differential Pressure	dPv	inches H_2O	5
Steam Temperature	Tv	deg F	34
Liquid Orifice Pressure	Pm	psia	7
Liquid Orifice Differential Pressure	dPm	inches H_2O	4
Liquid Mixing Point Pressure	Pf	psia	2
Liquid Mixing Point Temperature	Tf	deg F	40
Plant Inlet Pressure	P1	psia	9
Plant Inlet Temperature	T1	deg F	41
Plant Exhaust Pressure	P2	psia	3
Plant Exhaust Temperature	T2	deg F	35
Ambient Temperature	Ta	deg F	28
Atmospheric Pressure	Pa	psia	13
Throttle Position	trt tr	%	6
Separator Level	Ls	inches H_2O	16
Voltage	V	volts	30
Amperage	I	amps	31
Frequency	Hz	hertz	32
Electrical Power	KW	kilowatts	33

Table C-2. Variables Logged by the Data Acquisition System, Part 2 of 2

VARIABLE	SYMBOL	UNITS	VECTOR LOCATION
Journal Bearing Temperatures	LPJm	deg F	18
	LPJf	deg F	19
	HPJm	deg F	23
	HPJf	deg F	20
Thrust Bearing	THRf	deg F	21
	THRm	deg F	22
Alternator Bearing Temperatures	alt brg	deg F	36
		deg F	37
Alternator Winding Temperatures	alt wdg	deg F	24
		deg F	25
		deg F	26
		deg F	38
		deg F	39
Thrust Bearing Forces (Sensors Faulty)	Thr Brg Force		42
			43
Computer Reference Voltage	Vref		

Table C-3. Transducers (Ref. 7, Appendix D), Part 1 of 2

	VARIABLE	SYMBOL	MAKE	CALIBRATED RANGE	S/N	J
(1)	PRESSURE					
	Wellhead	Pw	Gould PA-1000-1000-15	0 to 600 psia	15001	1
	Steam Orifice	Pv	Rosemount 115-1GP8E22MB	0 to 300 psia	64061	8
	Steam Orifice Differential	dPm	Rosemount 115-1DP5E22MB	0 to 150 inches H_2O	89377	5
	Liquid Orifice	Pm	Gould PG1000-1000-11	0 to 300 psig	12172A	7
	Liquid Orifice Differential	dPm	Rosemount 115-1DP4E22MB	0 to 150 inches H_2O	90722 95286	4
	Liquid Mixing Point	Pf	Gould PA-1000-1000-15	0 to 300 psia	15000	2
	Plant Inlet	P1	Rosemount 115-1GP8E22MB	0 to 300 psig	64062	9
	Plant Exhaust	P2	Gould PA1000-0200-15	0 to 54 psia	15002	3
	Atmospheric	Pa	Gould PA1000-0050-15	0 to 50 psia	15004	13
	Separator Level	Ls	Rosemount 115-1DP5E22MB	0 to 150 inches H_2O	89379	16
(2)	TEMPERATURE	Resistance Thermometer Detectors Platinum 100 ohm at 0 deg C				
	Plant Inlet	T1		267 to 413 deg F	91	41
	Plant Exhaust	T2		54 to 243 deg F	94	35
	Steam Line	Tv		267 to 413 deg F	98	34

Table C-3. Transducers (Ref. C, Appendix D), Part 2 of 2

	VARIABLE	SYMBOL	MAKE	CALIBRATED RANGE	S/N	J
	Water Line	Tf		266 to 412 deg F	88	40
	Ambient	Ta			99	28
(3)	ELECTRICAL - Scientific Columbus Instruments					
	Voltage	V	VT100A2	120 volts		30
	Amperage	I	CT-510A2			
	Kilowatts	KW	DL31K5A2-2 Digilogic Model 5 50 hz	0 - 3333.33 watts		33
	Frequency	freq	Exceltronic 6281-B	45 - 55		32
(4)	OTHER					
	Throttle	trt	Bourns 5184 Linear position	0 to 100%		6

Table C-4. Test Chronology (Ref. C, Appendix E), Part 1 of 3

	AUGUST 1982
4.	Completion of the construction of the pipelines up to the anchors at the inlet and exhaust of the HSE.
20.	Fisher Vee 100 Ball Valve and Fisher 4195B pressure controller tests. Well discharging to waste.
26.	Safety valve discharge check. Full steam flow discharged through the safety valves.
	SEPTEMBER 1982
2.	HSE and load bank were delivered to site in a nine foot six high, forty foot long container.
8.	20 foot container with oil console and ancillary components delivered to site.
9.	Technical Specialists, Messrs. R. McKay and R. Sprankle, arrived on site. Data van delivered to site.
13.	HSE positioned in the shelter building.
13/24.	Site preparation continues.
24.	Completion of electrical wiring.
	Testing of computer equipment.
	One computer and one printer required repair by Hewlett-Packard.
27.	Start of the instrument calibration.
	OCTOBER 1982
4.	Computer programme modifications undertaken to suit the Broadlands BR 19 site.
11.	The load bank power cables were connected to HSE.
12.	The instruments were installed on the process pipelines and the power plant.
13.	Instrument calibration completed.

Table C-4. Test Chronology, Part 2 of 3

14. HSE run for the first time on geothermal fluid in New Zealand.

18. Faulty load bank relays replaced.

20. Start of 3333 rpm performance tests

22. Rotor inspection - no scale deposits evident. Iron sulphide on rotors and housing.

NOVEMBER 1982

3/5. IEA executive committee meetings held at MWD offices, Wairakei.

10. Voltage regulator instability observed.

12. 3333 rpm testing terminated, awaiting a replacement voltage regulator.

15. 2500 rpm gear set installed.

29. Replacement voltage regulator installed.

DECEMBER 1982

3. Start of 2500 rpm performance tests.

14. 2500 rpm tests completed.

FEBRUARY 1983

6. Start of the endurance test preparations.

21. Completion of test preparations including:

(a) Male low pressure seal replacement

(b) 3333 rpm gearset reinstalled

(c) Diatomite water filtration plant installed

24. Start of endurance test.

27. Intermittent fault in instrument power supply to high precision RTD temperature probes.

Table C-4. Test Chronology, Part 3 of 3

	MARCH 1983
4.	Fault in automatic shut down circuitry, shut down the plant for 1 hour.
16.	RTD power supply replaced.
	APRIL 1983
7.	Automatic grease system failed.
26.	Failure of the oil metering pumps.
	MAY 1983
3.	Endurance test terminated due to excessive oil loss across the shaft seals.
20.	Separator plant dismantled and returned to NZED Wairakei.
23.	Exhaust bend and bellows removed for HSE rotor inspection.
	JUNE 1983
10.	The HSE and the load bank were packed into the large container.
16.	The data van and the two containers were transported to Auckland in preparation for shipping to the USA.

Table C-5. Performance Calculation Procedure (Ref. C, Appendix C), Part 1 of 2

The computer programme to calculate the isentropic efficiency of the HSE was based on the programme used during the Utah tests. Refer to reference (3) for more detailed information than is contained in this appendix.

Minor changes were made to the programme for the New Zealand tests. There were:

(1) The flow rate calculations for the steam and water orifice plates were modified to conform to the British Standard, BS 1042 Part 1.

(2) The alternator power loss equation was modified for 50-Hz operation.

(3) The equation for the 3000 rpm (60 Hz) gear set was used to compute the gearbox power loss. This equation was derived from data supplied by the Philadelphia Gear Corporation who manufactured the gearbox (refer reference (1) p G-3).

A very brief outline of the calculation procedure and equations relevant to the New Zealand test site are detailed below.

CALCULATION PROCEDURE

(1) Flow rates computed to BS 1042 pt 1, 1964

Orifice plate diameters: (d)

Steam 5.[illegible]", 4.955", 4.396"

Water 4.396", 2.8263", 2.069"

Pipe Diameter (D)

Steam 7.990"

Water 7.983"

Flow rate equation:

$$W = 359.2\ CZeE(d)^2\sqrt{hp} \quad \text{(lbs/hr)}$$

eqtn (7), page 23, BS 1042 pt 1, 1964

(2) The enthalpy of fluid flowing into the plant was determined using measured temperatures and pressures to access the steam tables programmed in the computer.

Table C-5. Performance Calculation Procedure Part 2 of 2

(3) The quality of the fluid entering the plant is calculated from the known enthalpy and the measured fluid conditions at the plant inlet (P1).

(4) Compute the Shaft Power Output

Electrical Power generated is measured (KW)

Amperage is measured (I)

Alternator Power Loss Equation:

$a = 22.854 + 5.28 \times 10^{-6} I + .004 I^2$

This equation derived by R. McKay for 50-Hz operation

Gearbox Power Loss Equation:

$b = 8.559 + 6.975 \times (a + KW)/1000$

Refer to reference (1) p G-3 for more details

Shaft Power (KWM):

$KWM = KW + a + b$

(5) Isentropic efficiency calculation. Refer to the Utah computer programme (3) for details.

Table C-6. Variable List (Ref. C, Appendix B)

VARIABLE	SYMBOL	UNITS
Plant Inlet Pressure	P1	psia
Plant Inlet Temperature	T1	deg F
Inlet Fluid Quality	Q1	%
Inlet Enthalpy	H	btu/lb
Mass Flow Rate	M1	klbs/hr
Exhaust Pressure	P2	psia
Exhaust Temperature	T2	deg F
Throttle Opening	Tr	%
Electric Power Output	KWe	kW
Shaft Power Output	KWM	Hz
Frequency	Freq	Hz
Isentropic Efficiency	Eff	%
Data Cassette Number	DC	
Data Cassette Track	trk	
Data File	file	

Table C-7. Performance Test Results (Ref. C, Appendix B), Part 1 of 10

INLET PRESSURE (Psia) 100 INLET QUALITY (%) 100 RPM 3333

Date	Time	P1	T1	Q1	H	M1	P2	T2	Tr	KWe	KWM	Freq	Eff	DC	trk	file
		psia	oF	%	btu/lb	klb/h	psia	oF	%			Hz	%			
28/10/82	13:09:12	99.6	327.0	100.1	1187.9	15.9	14.2	210.0	19	110.3	143.3	49.9	21.6	1	1	168
27/10/82	11:51:48	100.0	327.1	100.1	1187.9	18.4	14.1	209.3	26	195.4	229.7	50.0	29.7	1	0	277
28/10/82	13:36:00	100.1	327.0	100.1	1188.2	19.3	14.2	209.8	27	197.1	231.4	50.1	28.7	1	1	179
28/10/82	14:03:33	98.5	325.6	100.1	1188.2	21.1	14.2	209.8	34	254.1	289.5	49.9	33.1	1	1	190
27/10/82	12:13:42	98.8	326.0	100.1	1187.9	20.7	14.1	209.2	33	259.6	295.0	50.1	34.1	1	1	4
27/10/82	12:41:20	102.6	328.3	100.1	1188.7	23.6	14.1	209.3	42	342.0	379.0	49.8	37.8	1	1	25
28/10/82	14:40:09	102.5	327.9	100.2	1189.1	24.4	14.2	209.8	43	343.4	380.4	50.0	36.8	1	1	201
28/10/82	15:04:47	100.7	326.4	100.2	1189.0	26.3	14.2	209.8	56	398.0	436.2	50.1	39.6	1	1	212
27/10/82	13:00:26	100.2	325.8	100.2	1188.6	27.3	14.1	209.2	70	448.6	487.4	50.1	42.5	1	1	36
27/10/82	13:18:06	98.9	324.5	100.2	1186.5	28.6	14.1	209.2	96	486.6	525.7	50.6	43.6	1	1	47

INLET PRESSURE (Psia) 140 INLET QUALITY (%) 100 RPM 3333

Date	Time	P1	T1	Q1	H	M1	P2	T2	Tr	KWe	KWM	Freq	Eff	DC	trk	file
		psia	oF	%	btu/lb	klb/h	psia	oF	%			Hz	%			
28/10/82	16:26:45	140.6	352.6	100.1	1193.6	20.6	14.2	209.9	16	201.0	235.6	50.0	24.0	1	1	[illegible]
27/10/82	13:44:52	140.7	352.8	100.1	1193.6	22.4	14.0	209.1	20	284.9	320.9	50.0	29.2	1	1	58
28/10/82	16:09:46	140.3	352.4	100.1	1193.7	23.6	14.2	209.7	20	285.5	321.5	50.0	26.6	1	1	245
28/10/82	15:53:28	140.3	352.4	100.1	1193.8	24.6	14.2	209.7	23	335.1	371.9	50.0	30.9	1	1	234
27/10/82	14:13:44	140.0	352.1	100.1	1193.6	24.3	14.0	209.2	23	342.6	379.6	50.0	31.8	1	1	69
28/10/82	15:32:38	140.6	352.1	100.1	1194.0	26.3	14.2	209.7	30	445.5	484.3	50.3	35.0	1	1	223
27/10/82	14:37:22	139.2	351.4	100.1	1193.6	27.6	14.0	209.1	31	453.3	492.2	50.0	[illegible]	1	1	80
27/10/82	15:03:12	139.6	351.4	100.1	1193.8	30.6	14.1	208.9	38	538.3	578.9	50.1	38.6	1	1	91
27/10/82	15:34:40	138.4	350.2	100.1	1193.8	33.6	14.1	208.9	49	626.6	669.1	49.9	40.6	1	1	102
27/10/82	15:52:39	139.7	350.7	100.1	1194.1	36.5	14.1	208.9	63	710.3	754.8	49.9	42.3	1	1	113
27/10/82	16:10:53	139.9	350.4	100.1	1194.2	38.3	14.1	208.9	75	762.8	808.6	50.0	43.1	1	1	124

INLET PRESSURE (Psia) 180 INLET QUALITY (%) 100 RPM 3333

Date	Time	P1	T1	Q1	H	M1	P2	T2	Tr	KWe	KWM	Freq	Eff	DC	trk	file
		psia	oF	%	btu/lb	klb/h	psia	oF	%			Hz	%			
27/10/82	16:32:23	179.5	371.6	100.1	1197.4	33.5	14.0	209.0	27	611.0	653.5	50.0	36.0	1	1	135
27/10/82	16:51:00	181.6	372.6	100.1	1197.6	36.3	14.1	209.1	31	695.6	740.0	50.1	37.5	1	1	146
27/10/82	17:10:51	180.2	371.6	100.1	1197.6	38.5	14.1	208.8	36	758.6	804.8	50.0	38.5	1	1	157

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Table C-7. Performance Test Results, Part 2 of 10

INLET PRESSURE (Psia) 100 INLET QUALITY (%) 50 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
02/11/82	12:23:47	100.7	327.4	53.0	769.8	31.4	14.3	210.6	31	196.5	230.9	50.1	31.4	1	1	278
02/11/82	12:47:28	99.4	325.8	49.5	738.1	38.8	14.3	210.5	45	283.9	319.6	50.0	37.5	2	0	14
02/11/82	14:03:41	99.4	325.5	51.9	759.3	41.2	14.3	210.5	57	348.3	385.3	50.0	40.8	2	0	47
02/11/82	14:23:37	100.4	325.4	49.6	739.1	48.6	14.3	210.9	83	431.5	470.2	50.1	43.8	2	0	58

INLET PRESSURE (Psia) 140 INLET QUALITY (%) 50 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
02/11/82	16:12:10	139.7	352.4	48.3	744.1	33.7	14.4	210.6	18	197.9	232.4	50.0	26.5	2	0	102
02/11/82	15:36:59	139.9	352.1	50.3	761.4	37.4	14.3	210.5	23	277.4	313.2	49.8	31.6	2	0	91
02/11/82	15:07:11	140.9	352.6	48.7	747.9	42.0	14.4	210.5	26	340.4	377.5	50.0	34.7	2	0	88
02/11/82	14:47:26	142.1	352.7	50.3	762.3	47.7	14.4	210.5	36	456.0	488.9	50.0	38.4	2	0	67
08/11/82	17:17:26	141.1	351.7	49.3	753.3	53.6	14.4	210.4	45	537.7	578.4	49.8	41.3	2	0	179
08/11/82	17:29:12	140.5	350.8	50.0	759.1	58.3	14.3	210.9	59	621.3	663.9	50.0	43.[illegible]	2	[illegible]	[illegible]
08/11/82	17:46:59	140.9	350.7	51.0	768.3	61.7	14.3	210.5	72	692.7	737.1	50.1	44.3	2	0	201

INLET PRESSURE (Psia) 180 INLET QUALITY (%) 50 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
09/11/82	16:59:14	179.5	372.[illegible]	49.5	767.1	43.4	14.3	210.2	19	372.9	410.5	50.0	32.2	2	1	[illegible]
09/11/82	16:39:15	179.7	372.0	50.8	776.3	47.0	14.4	210.2	23	450.5	489.4	50.0	34.7	2	1	36
09/11/82	16:19:26	179.9	371.8	50.9	779.3	52.2	14.3	210.2	26	536.1	576.8	50.1	36.7	2	1	25
09/11/82	16:08:46	179.5	371.5	49.7	768.4	57.8	14.2	210.5	33	619.6	662.4	50.1	38.9	2	1	14
09/11/82	15:56:05	179.9	371.1	49.6	769.7	62.6	14.3	210.5	40	703.8	748.3	50.0	40.4	2	0	[illegible]
09/11/82	15:39:52	180.9	371.3	49.9	771.0	[illegible]	14.3	210.5	44	760.9	806.8	50.3	41.0	2	[illegible]	[illegible]

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Table C-7. Performance Test Results, Part 3 of 10

INLET PRESSURE (Psia) 100   INLET QUALITY (%) 25   RPM 3333

Date	Time	P1	T1	Q1	H	M1	P2	T2	Tr	KWe	KWM	Freq	Eff	DC	trk	file
		psia	oF	%	btu/lb	klb/h	psia	oF	%			Hz	%			
02/11/82	11:52:07	100.6	327.2	25.7	526.9	53.5	14.4	210.8	38	196.6	231.0	49.9	33.7	1	1	267
02/11/82	13:20:27	99.3	325.5	23.6	508.0	66.6	14.4	210.8	56	279.5	315.3	49.9	39.7	2	0	25
02/11/82	13:40:10	98.6	324.5	26.5	533.0	69.8	14.4	210.9	72	347.3	384.3	49.9	42.5	2	0	36

INLET PRESSURE (Psia) 140   INLET QUALITY (%) 25   RPM 3333

Date	Time	P1	T1	Q1	H	M1	P2	T2	Tr	KWe	KWM	Freq	Eff	DC	trk	file
		psia	oF	%	btu/lb	klb/h	psia	oF	%			Hz	%			
08/11/82	13:52:18	139.1	351.9	24.8	539.9	52.5	14.3	210.6	21	198.9	233.5	49.9	29.3	2	0	113
08/11/82	14:24:29	139.6	351.4	25.3	543.8	60.6	14.2	210.6	28	280.7	316.6	49.9	34.0	2	0	124
08/11/82	14:41:30	140.6	352.1	25.9	550.1	67.5	14.3	210.7	34	359.8	397.3	50.1	37.4	2	0	135
08/11/82	15:06:13	138.9	350.5	24 4	536.3	81.4	14.3	210.8	47	456.3	495.3	49.9	46.7	2	0	146
08/11/82	15:26:15	139.4	350 3	25.7	547.5	87.7	14.4	210.8	58	539.0	579.8	50.1	42.6	2	0	15[illegible]
08/11/82	15:53:08	140.4	350.1	25.8	548.6	96.9	14.4	210.9	73	618 7	661.2	49.9	44.2	2	0	1[illegible]

INLET PRESSURE (Psia) 180   INLET QUALITY (%) 25   RPM 3333

Date	Time	P1	T1	Q1	H	M1	P2	T2	Tr	KWe	KWM	Freq	Eff	DC	trk	file
		psia	oF	%	btu/lb	klb/h	psia	oF	%			Hz	%			
09/11/82	17:29:36	179 2	373.2	25.3	561.4	59.0	14.3	210.5	18	281.5	317.4	50.1	30.5	2	1	69
09/11/82	17:16:11	179.4	372 1	25.5	562.4	67.5	14.3	210.6	23	369.3	406.9	50.0	34.1	2	1	53
09/11/82	13:05:25	180.5	372 4	25.3	561.6	76.2	14.4	211.0	28	450.5	489.4	49.9	36.5	2	0	212
09/11/82	13:31:40	179.5	371.4	24.4	553.5	87.0	14.3	210.9	35	546.7	587.5	49.9	39 4	2	0	223
09/11/82	14:12:12	180.1	371.4	25.2	568.6	92.4	14.4	211.1	41	621.2	663.7	50.0	41.5	2	0	234
09/11/82	14.25:05	179 4	370.6	25.5	562.6	102.2	14.4	211.0	50	704.4	749.0	49.9	41.6	2	0	245
09/11/82	14.54:0[illegible]	180 2	370.6	25.7	564.5	106.5	14.5	211.0	56	761.5	807.5	50.0	42.6	2	0	256

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Table C-7. Performance Test Results, Part 4 of 10

INLET PRESSURE (Psia) 100 INLET QUALITY (%) 10 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
10/11/82	11:37:34	99.4	325.9	10.1	387.5	98.5	14.4	211.1	50	205.0	239.4	49.9	36.3	2	1	80
10/11/82	11:56:41	100.1	325.6	10.1	388.6	115.7	14.4	211.1	68	282.6	318.4	50.1	40.7	2	1	91
10/11/82	12:23:06	98.9	323.5	10.1	387.2	133.2	14.4	211.4	93	346.3	383.9	50.1	43.2	2	1	102

INLET PRESSURE (Psia) 140 INLET QUALITY (%) 10 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
10/11/82	13:12:38	138.7	351.8	9.2	403.7	109.0	14.3	211.0	33	279.2	314.9	50.1	35.4	2	1	123
10/11/82	13:31:05	139.3	351.6	10.0	411.5	117.4	14.4	211.1	42	358 4	395.6	50.0	39.4	2	1	134
10/11/82	13:44:26	142 1	351.[illegible]	9 7	410.0	137.4	14.5	211.4	55	458.7	489 6	50.0	42.0	2	1	145
10/11/82	14:02.13	139 6	35[illegible] 2	10 6	417.9	151.4	14.7	212.0	71	532.2	572.6	49.8	43.1	2	1	15[illegible]
10/11/82	14:24·36	13[illegible].5	349.2	10.6	416.5	172.1	14.6	212.7	90	614.9	657.4	49.[illegible]	43.9	2	1	167

INLET PRESSURE (Psia) 18[illegible] INLET QUALITY (%) 1[illegible] RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
10/11/82	14:45.32	18[illegible] 2	37[illegible] 9	[illegible].9	43[illegible].[illegible]	157.5	14.7	212.3	49	615.9	658.4	5[illegible].[illegible]	4[illegible]	2	[illegible]	17[illegible]

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Table C-7. Performance Test Results, Part 5 of 10

INLET PRESSURE (Psia) 100 INLET QUALITY (%) 0 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
20/10/82	12:55:23	102.3	328.7	0.0	299.3	174.3	14.3	211.1	14	113.6	146.7	49.8	29.2	1	0	14
20/10/82	13:56:55	101.4	328.7	0.1	300.5	235.0	14.5	211.3	41	199.5	233.8	50.1	34.3	1	0	25
20/10/82	14:14:32	99.1	325.6	0.4	301.5	304.6	14.8	212.4	84	273.0	308.6	50.0	35.0	1	0	36

INLET PRESSURE (Psia) 140 INLET QUALITY (%) 0 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
20/10/82	16:43:13	142.6	352.6	0.0	324.3	166.6	14.2	210.9	9	194.6	228.9	49.9	33.3	1	0	102
20/10/82	15:05:14	141.[illegible]	352.9	0.0	324.7	212.4	14.5	211.9	15	274.9	310.6	49.9	35.6	1	0	[illegible]
20/10/82	16:24:23	141.4	353.3	0.0	325.1	214.8	14.5	211.8	16	278.9	314.6	50.0	35.6	1	0	[illegible]
20/10/82	15:22:07	139.4	352.3	0.1	325.2	264.6	14.6	212.7	36	365.2	402.4	50.0	37.4	1	0	[illegible]
20/10/82	15:44:47	141.5	353.0	0.3	327.9	316.5	15.1	214.1	58	448.4	467.3	49.9	[illegible]	1	0	[illegible]
20/10/82	15:57:26	13[illegible].9	350.5	0.5	328.1	358.6	15.5	215.3	83	498.2	538.1	50.1	[illegible]	1	0	[illegible]

INLET PRESSURE (Psia) 180 INLET QUALITY (%) 0 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
21/10/82	12:55:03	179.2	371.9	0.0	344.8	189.1	14.5	212.3	11	323.5	360.0	49.8	36.5	1	0	113
21/10/82	13:23:04	179.3	371.8	0.0	344.7	212.1	14.6	212.1	13	367.5	404.8	50.0	36.8	1	0	124
21/10/82	13:54:22	177.8	371.8	0.0	345.1	247.6	14.9	212.9	23	448.9	467.6	49.9	38.5	1	0	14[illegible]
21/10/82	14:16:44	181.[illegible]	373.[illegible]	0.1	347.1	285.8	15.1	213.7	33	535.2	575.6	50.0	38.7	1	0	156
21/10/82	14:30:59	177.3	370.6	0.3	347.2	342.5	15.4	215.2	57	621.6	664.2	49.9	37.8	1	0	167
26/10/82	12:26:27	179.4	371.5	0.4	348.8	371.6	15.7	216.1	65	673.7	717.8	50.0	37.3	1	0	1[illegible]
26/10/82	12:29:43	178.9	371.2	0.4	348.7	369.8	15.6	216.2	67	674.8	718.9	50.0	37.7	1	0	2[illegible]
21/10/82	14:42:40	180.6	371.6	0.4	349.7	395.3	16.1	217.7	74	709.2	753.9	50.1	37.1	1	0	17[illegible]

INLET PRESSURE (Psia) 220 INLET QUALITY (%) 0 RPM 3333

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
26/10/82	13:04:12	220.9	389.8	0.0	364.6	301.9	15.2	214.5	28	676.6	720.8	50.0	38.3	1	0	222
26/10/82	13:26:04	220.0	389.4	0.1	364.7	314.3	15.3	214.7	33	710.1	755.2	50.0	38.6	1	0	243
26/10/82	13:26:59	220.0	389.4	0.1	364.7	315.0	15.3	214.7	33	709.8	754.9	50.0	38.5	1	0	244
26/10/82	13:50:59	218.9	388.9	0.2	365.0	339.6	15.5	215.9	40	755.1	801.4	50.0	38.1	1	0	265
26/10/82	13:52:17	218.7	388.8	0.2	365.0	338.8	15.5	215.9	40	755.4	801.6	50.0	38.2	1	0	266

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Table C-7. Performance Test Results, Part 6 of 10

INLET PRESSURE (Psia) 100 INLET QUALITY (%) 100 RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
13/12/82	11:32:58	100.3	327.4	100.0	1187.6	14.6	14.0	210.6	16	110.3	143.4	49.7	23.3	3	1	25[illegible]
13/12/82	10:27:51	100.1	327.0	100.1	1187.9	18.3	14.1	210.5	25	198.2	232.6	49.8	30.3	3	1	223
13/12/82	10:44:35	100.3	327.0	100.1	1188.1	20.4	14.0	210.5	33	254.7	290.2	49.8	33.7	3	1	234
13/12/82	13:16:39	100.3	326.5	100.1	1188.2	24.2	14.1	210.6	55	342.8	380.1	49.7	37.5	3	1	267
13/12/82	1[illegible]:00:06	99.6	326.0	100.1	1188.4	24.0	14.0	210.7	56	343.6	380.7	49.9	37.9	3	1	245
13/12/82	13:34:14	99.6	326.2	100.1	1188.3	26.6	14.1	210.5	84	401.3	440.0	49.9	39.6	3	1	2[illegible]

INLET PRESSURE (Psia) 140 INLET QUALITY (%) 100 RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
10/12/82	13:55:39	141.0	353.2	100.0	1193.5	15.1	14.2	211.1	14	202.1	236.6	49.8	25.4	3	1	203
10/12/82	13:42:51	139.5	352.0	100.1	1193.4	22.5	14.2	211.1	20	286.9	323.0	49.9	29.4	3	1	20[illegible]
10/12/82	13:30:15	138.7	351.5	100.1	1193.4	24.2	14.2	211.0	23	334.7	371.6	49.8	31.9	3	1	19[illegible]
10/12/82	13:1[illegible]:3[illegible]	139.8	351.9	100.1	1193.6	26.6	14.3	210.9	34	453.1	492.4	49.8	35.0	3	1	1[illegible]
13/12/82	13:59:29	139.7	351.9	100.1	1193.6	29.1	14.1	210.4	34	454.2	493.6	49.7	34.7	4	0	14
13/12/82	14:19:15	138.5	351.0	100.1	1193.6	32.3	14.1	210.2	48	536.8	577.9	49.8	36.6	4	0	25
13/12/82	14:43:45	139.2	350.9	100.1	1193.9	35.9	14.2	210.1	73	626.2	669.4	49.8	38.2	4	0	36

INLET PRESSURE (Psia) 180 INLET QUALITY (%) 100 RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
10/12/82	12:35:49	181.0	372.8	100.0	1197.3	26.5	14.3	210.9	16	371.9	409.9	50.0	28.6	3	1	168
10/12/82	12:20:38	179.8	372.1	100.1	1197.3	29.3	14.2	210.8	20	450.2	489.6	49.9	31.0	3	1	15[illegible]
10/12/82	11:58:47	179.8	371.9	100.1	1197.4	32.4	14.3	210.7	25	535.5	576.9	50.1	33.0	3	1	146
13/12/82	15:05:39	180.5	372.4	100.1	1197.4	32.9	14.2	210.1	25	535.6	577.6	49.8	32.4	4	0	47
13/12/82	15:22:[illegible]3	180.3	372.1	100.1	1197.5	35.6	14.2	210.0	30	611.4	655.0	49.8	33.9	4	0	58
13/12/82	15:36:45	180.8	372.1	100.1	1197.6	37.0	14.3	210.0	38	696.1	741.8	49.8	35.2	4	0	69
13/12/82	15:48:13	179.6	371.3	100.1	1197.6	41.6	14.1	209.9	48	760.0	806.8	49.8	35.8	4	0	80
13/12/82	15:59:24	179.6	371.0	100.1	1197.7	45.2	14.2	209.5	67	849.4	897.8	49.8	36.7	4	0	91

Table C-7. Performance Test Results, Part 7 of 10

INLET PRESSURE (Psia) 100   INLET QUALITY (%) 50   RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
09/12/82	12:42:33	100.2	327.1	50.5	747.1	30.3	14.2	211.5	29	19[illegible].6	229.1	49.9	33.7	3	0	267
09/12/82	13:04:25	99.1	326.0	51.1	751.8	36.3	14.3	211.5	46	280.3	316.2	50.2	38.7	3	[illegible]	278
09/12/82	13:42:26	98.9	325.3	49.3	736.3	41.6	14.4	211.5	68	341.6	378.9	50.0	41.8	3	1	1[illegible]

INLET PRESSURE (Psia) 140   INLET QUALITY (%) 50   RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
09/12/82	14:29:24	139.0	352.2	49.9	757.7	31.0	14.3	211.4	16	198.3	232.9	49.7	28.6	3	1	3[illegible]
09/12/82	14:14:0[illegible]	139.2	352.0	51.1	768.0	36.1	14.2	211.4	22	277.9	313.9	49.8	32.4	3	1	25
09/12/82	14:47:41	140.3	352.1	50.9	766.7	40.0	14.3	211.4	26	339.8	377.1	50.3	35.1	3	1	4[illegible]
09/12/82	15:45:02	137.7	351.4	50.1	759.0	48.1	14.3	211.6	43	457.7	497.1	49.7	39.4	3	1	5[illegible]
10/12/82	09:07:27	140.1	351.6	49.6	755.4	54.1	14.2	211.7	57	538.5	579.9	50.2	40.7	3	1	6[illegible]
10/12/82	09:28:43	139.8	351.0	50.7	760.3	58.3	14.2	211.7	79	606.2	649.1	49.8	41.5	3	1	6[illegible]

INLET PRESSURE (Psia) 180   INLET QUALITY (%) 50   RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
10/12/82	09:59:44	180.3	372.6	49.5	767.7	43.0	14.3	211.4	19	374.6	412.6	50.0	32.6	3	1	91
10/12/82	10:12:16	180.0	372.2	49.8	769.6	48.1	14.3	211.5	24	450.3	489.9	49.9	34.[illegible]	3	1	102
10/12/82	10:36:50	180.1	372.0	49.7	769.3	53.6	14.4	211.5	30	536.5	577.9	50.0	36.6	3	1	113
10/12/82	10:55:42	180.3	371.9	49.9	770.6	59.0	14.3	211.5	37	620.4	663.8	50.1	38.0	3	1	124
08/12/82	15:33:09	181.6	372.1	49.6	768.4	65.5	14.2	211.6	47	700.9	746.3	49.9	38.4	3	0	245
10/12/82	11:23:55	179.8	370.9	50.4	775.2	68.4	14.3	211.4	59	761.0	807.9	49.8	39.6	3	1	135
08/12/82	15:59:12	179.7	370.6	50.0	771.7	71.3	14.2	211.3	65	766.2	833.5	50.0	39.4	3	0	256

Table C-7. Performance Test Results, Part 8 of 10

INLET PRESSURE (Psia) 100 INLET QUALITY (%) 25 RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
07/12/82	11:37:53	101.0	327.3	25.9	529.6	50.2	14.2	210.2	34	197.0	231.6	50.6	35.4	3	0	59
07/12/82	12:02:38	99.7	325.4	25.2	522.3	61.6	14.2	210.4	54	278.9	314.9	50.0	40.4	3	0	70
07/12/82	12:26:06	99.9	325.1	25.2	522.6	70.2	14.2	210.4	77	340.9	378.0	49.9	42.6	3	0	81

INLET PRESSURE (Psia) 140 INLET QUALITY (%) 25 RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
07/12/82	12:54:33	140.5	352.6	25.0	542.3	59.0	14.2	210.2	26	278.1	314.1	50.1	34.7	3	0	92
07/12/82	13:23:06	140.1	352.0	24.3	535.5	56.8	14.2	210.2	19	260.2	234.8	49.8	36.8	3	[illegible]	102
07/12/82	[illegible]	[illegible]	351.2	25.0	541.7	66.9	14.3	210.2	35	359.7	397.1	49.7	37.6	3	[illegible]	114
07/12/82	14:10:35	139.0	[illegible]	25.2	547.9	79.1	14.3	210.2	50	459.6	499.0	50.3	40.5	3	0	[illegible]
07/12/82	14:57:16	140.3	356.7	25.3	545.0	90.6	14.3	210.3	66	536.3	577.3	50.0	41.3	3	0	[illegible]
07/12/82	15:18:45	140.3	[illegible]	25.2	543.6	[illegible]	14.4	210.4	89	595.2	637.0	49.9	41.6	3	[illegible]	[illegible]

INLET PRESSURE (Psia) 180 INLET QUALITY (%) 25 RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
08/12/82	12:50:20	180.6	372.5	25.7	555.3	58.1	14.3	211.5	16	279.0	315.0	49.6	36.3	3	[illegible]	[illegible]
08/12/82	13:16:37	[illegible]	372.1	24.2	556.7	69.6	14.2	211.6	23	369.8	407.5	50.1	33.5	3	[illegible]	[illegible]
08/12/82	13:35:54	179.7	372.1	24.6	557.2	77.0	14.3	211.5	26	449.2	486.5	50.0	36.5	3	0	[illegible]
08/12/82	13:58:16	180.1	371.7	25.3	563.1	86.5	14.4	211.6	37	545.9	587.2	49.8	38.2	3	0	[illegible]
08/12/82	14:14:46	179.6	371.2	[illegible]	559.0	96.8	14.4	211.8	46	620.3	663.7	49.9	39.3	3	[illegible]	[illegible]
08/12/82	[illegible]	179.7	[illegible]	24.6	[illegible]	107.9	14.4	212.0	56	701.2	746.6	50.0	[illegible]	3	[illegible]	234
08/12/82	14:43:57	[illegible]	370.0	25.8	554.6	111.7	14.5	212.1	69	749.6	796.3	49.7	40.3	3	0	225

Table C-7. Performance Test Results, Part 9 of 10

INLET PRESSURE (Psia) 100   INLET QUALITY (%) 10   RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
03/12/82	10:55:48	100.1	326.2	10.1	388.4	89.9	14.3	210.5	44	203.9	238.5	50.2	39.2	2	1	190
03/12/82	11:26:06	101.3	325.5	9.7	385.9	112.1	14.3	210.6	66	282.2	318.2	50.2	42.4	2	1	201
03/12/82	11:50:34	100.0	325.0	10.1	387.8	123.4	14.3	210.7	80	317.8	354.5	49.8	42.6	2	1	212

INLET PRESSURE (Psia) 140   INLET QUALITY (%) 10   RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
03/12/82	12:44:50	140.3	352.0	10.8	418.5	96.7	14.2	210.4	30	279.6	315.8	49.9	36.4	2	1	233
03/12/82	13:18:26	140.2	351.6	10.1	412.6	115.3	14.3	210.6	40	353.3	390.9	49.9	39.2	2	1	244
03/12/82	13:48:08	139.2	350.6	9.9	409.7	146.2	14.3	210.8	56	447.4	486.6	49.8	41.0	2	1	[illegible]
03/12/82	14:11:56	140.1	350.3	10.1	412.5	159.9	14.6	211.3	78	530.5	571.7	50.1	41.6	2	1	[illegible]

INLET PRESSURE (Psia) 180   INLET QUALITY (%) 10   RPM 2500

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
03/12/82	17:04:17	176.7	371.1	10.5	434.8	106.5	14.3	210.4	26	365.7	403.2	49.7	38.5	3	0	43
03/12/82	15:09:27	180.0	371.7	10.0	430.7	122.8	14.3	210.6	32	447.5	486.8	50.0	39.1	2	1	277
03/12/82	15:35:36	[illegible]	[illegible]	10.2	432.3	141.2	14.4	210.9	42	534.3	575.5	50.3	39.9	3	0	5
03/12/82	15:51:5[illegible]	[illegible]	[illegible]	9.9	430.7	161.1	14.5	211.5	52	614.7	657.9	50.2	40.3	3	0	16
03/12/82	16:15:30	[illegible]	[illegible]	10.2	433.2	174.4	14.6	211.9	63	677.2	722.2	49.6	40.6	3	0	[illegible]

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Table C-7. Performance Test Results, Part 10 of 10

INLET PRESSURE (Psia) 100 INLET QUALITY (%) 0 RPM 2500

Date	Time	Pi psia	T1 oF	Qi %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
14/12/82	09:16:28	98.6	326.1	0.0	297.4	151.0	14.3	212.0	10	113.5	146.6	50.0	34.7	4	0	102
14/12/82	09:36:03	98.8	327.0	0.1	298.6	212.1	14.5	212.4	33	200.3	234.7	50.2	39.2	4	0	114
14/12/82	09:53:57	99.5	326.6	0.4	301.2	283.0	14.8	214.2	72	276.2	311.7	49.9	38.3	4	0	126

INLET PRESSURE (Psia) 140 INLET QUALITY (%) 0 RPM 2500

Date	Time	Pi psia	T1 oF	Qi %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
14/12/82	10:12:30	141.9	354.2	0.0	326.0	192.8	14.6	212.7	12	275.1	310.9	49.7	36.9	4	0	137
14/12/82	10:32:33	139.8	352.8	0.2	326.1	248.7	14.8	214.0	34	365.7	403.1	49.8	39.5	4	0	146
14/12/82	10:51:48	139.2	351.9	0.3	326.7	317.1	15.3	215.9	60	446.7	466.0	49.9	36.0	4	0	159
14/12/82	11:11:51	140.4	351.6	0.4	326.4	364.1	15.6	217.7	80	497.8	537.8	49.8	36.3	4	0	170

INLET PRESSURE (Psia) 180 INLET QUALITY (%) 0 RPM 2500

Date	Time	Pi psia	T1 oF	Qi %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
14/12/82	12:20:16	178.6	371.8	0.0	344.7	163.1	14.5	212.9	6	322.7	359.5	49.6	37.6	4	0	192
14/12/82	12:40:36	181.7	373.5	0.1	345.6	204.2	14.7	213.9	10	367.1	464.8	50.0	37.7	4	0	203
14/12/82	11:53:49	182.6	374.3	0.0	347.5	239.9	14.9	214.6	18	449.6	488.6	50.0	35.7	4	0	18[illegible]
14/12/82	13:02:29	179.1	372.3	0.2	347.1	289.7	15.2	215.7	36	536.2	577.3	50.0	35.5	4	0	214
14/12/82	13:23:22	179.0	372.1	0.3	346.3	3[illegible]7.4	15.6	217.7	50	622.8	666.0	50.1	37.1	4	0	225
14/12/82	13:45:03	181.4	372.6	0.4	347.8	379.7	16.1	219.2	66	674.3	719.0	50.2	36.8	[illegible]	0	23[illegible]

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Table C-8. Endurance Test Record (Ref. C, Appendix B), Part 1 of 10

Date	Time	P1 psia	T1 oF	G1 %	h btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWh	Freq Hz	Eff %	DC	trk	file
24/02/82	16:48:18	176.8	368.2	25.7	564.1	111.9	14.6	211.6	61	809.4	856.9	49.6	43.5	5	0	7
24/02/82	20:48:23	181.5	369.7	25.8	566.4	112.1	14.6	211.5	58	810.8	858.4	49.9	43.0	5	0	11
25/02/82	00:48:29	181.6	370.0	25.5	563.3	110.9	14.5	211.6	57	807.2	854.7	50.0	43.6	5	0	15
25/02/82	04:07:38	181.4	370.1	25.6	564.7	111.4	14.6	211.5	56	806.5	854.0	49.9	43.3	5	0	19
25/02/82	08:07:44	181.0	369.7	25.8	566.2	111.2	14.4	211.6	58	809.2	856.8	49.8	43.1	5	0	23
25/02/82	12:07:51	179.1	369.0	25.9	565.9	110.3	14.6	211.5	59	802.3	849.8	49.8	43.4	5	0	27
25/02/82	16:07:57	178.9	368.9	25.8	565.5	111.5	14.5	211.5	60	810.2	857.8	50.0	43.4	5	0	31
25/02/82	20:08:02	179.1	370.0	25.8	565.6	111.8	14.5	211.5	60	813.1	860.8	50.0	43.4	5	0	35
26/02/82	00:08:07	180.0	369.9	25.6	563.8	111.1	14.6	211.7	59	808.8	356.4	49.9	43.8	5	0	39
26/02/82	04:08:13	180.6	370.8	25.6	564.1	111.3	14.4	211.4	58	807.2	854.8	49.9	43.3	5	0	43
26/02/82	08:08:19	181.6	370.7	25.2	561.4	112.4	14.6	211.4	57	809.8	857.5	50.0	43.5	5	0	47
26/02/82	12:08:26	179.3	369.6	25.8	565.6	111.3	14.4	211.3	59	808.7	856.4	49.8	43.3	5	0	51
26/02/82	16:08:33	17[illegible].7	372 0	26.1	567.5	111.1	14.5	211.3	61	809.6	857.2	49.9	43.3	5	0	55
26/02/82	20:40:03	179.2	370 2	25.6	563.5	112.1	14.5	211.4	59	810.1	857.6	50.0	43.4	5	0	59
27/02/82	00:40:06	180.3	370 4	25 4	562.0	112.2	14.5	211.5	58	808.0	855.6	49.9	43.4	5	0	6[illegible]
27/02/82	04:40:12	180 4	370.9	25 6	563.9	111.3	14.6	211.4	58	807.7	855.4	49 9	43 3	5	0	67
27/02/82	08:40:13	180.3	369.5	25.3	561 3	112.5	14.5	211.5	58	80[illegible].1	854.7	49 9	43.3	5	0	71
27/02/82	12:40:22	178 [illegible]	369.8	25.[illegible]	564.4	111.5	14.5	211.7	60	809 6	857.5	49.9	43.5	5	[illegible]	[illegible]
27/02/82	16:40:27	17[illegible].6	370.2	25.6	563.6	111.7	14.5	211.1	59	810 3	858.0	49.9	43.5	5	0	[illegible]
27/02/82	20:41:41	180 2	369 9	25.5	563.3	111.4	14.5	211.3	56	810.2	857.9	49.9	43.6	5	[illegible]	83
28/02/82	00:41:44	180.7	373 4	25 3	561.9	112 1	14.5	211.4	58	812 1	859.9	49.6	43.6	5	0	87
28/02/82	04:41 51	181.2	371.6	25 4	562.9	111.5	14.4	211.0	57	806.4	854.0	49.9	43.3	5	[illegible]	9[illegible]
28/02/82	08:41:58	180.6	371.1	25.4	562 4	111.3	14.3	211.3	57	809.4	857.1	49 8	43.5	5	0	95
28/02/82	12:42:03	178.2	369 5	25.9	565.6	110.3	14.5	211 3	60	808.7	856.4	50.0	43 [illegible]	5	0	[illegible]
28/02/82	16:42:06	178.0	369.5	25 6	562.6	111.8	14.5	211.0	60	810.3	857.9	49.9	43.6	5	0	103
28/02/82	20:42.15	179.3	370 2	25 7	564 6	110.9	14 5	211.0	56	809.0	856.7	49.9	4[illegible].6	5	0	10[illegible]
01/03/82	14:34:3[illegible]	176.0	367.5	25.7	563.5	111.3	14.5	210.6	59	809.7	857.3	49 [illegible]	43 [illegible]	5	0	111
01/03/82	18:34:34	179 8	370.3	25 7	564.6	110.2	14.4	210.8	55	808 5	856.1	49.9	43.8	5	0	115
01/03/82	22:34:41	180 8	370.7	25 4	562.1	111.8	14.4	210.9	57	808.7	856.3	49.9	43.4	5	0	11[illegible]
02/03/82	02.16:22	181.1	370.6	25 5	563.4	110.1	14.4	210.7	57	806.6	854.4	49.9	43.6	5	0	12[illegible]
02/03/82	06:18:28	180.5	370.8	25 5	563 0	110.[illegible]	14.5	210.7	57	806.9	854.5	50.0	44.0	5	0	12[illegible]
02/03/82	10:18:34	179 5	370.1	25.4	562.3	110.6	14.5	210.9	58	806.6	854.2	49.9	44.0	5	0	131
02/03/82	14:18:39	177.4	369.2	25.6	564.8	109.8	14.4	210.9	60	808.2	855.8	49.8	44.0	5	0	135
02/03/82	18:18:46	177.5	370.3	26.0	566.0	110.0	14.4	210.9	66	810.6	858.2	49.8	43.9	5	0	13[illegible]
02/03/82	22:18:52	179.9	370.5	25.5	562.9	110.4	14.5	210.9	58	80[illegible].7	856.3	49.9	44.0	5	0	143
03/03/82	02:19:39	180.4	370.8	25.7	564.9	109.8	14.5	211.1	57	807.3	854 9	49.9	43.9	5	0	148
03/03/82	06:19:47	179.9	371.3	25.7	564.4	109.5	14.4	210.9	57	807.0	854.6	49.9	44.0	5	0	152
03/03/82	10:19:53	180.0	373.1	26.1	568.4	110.2	14.3	210.7	57	807.4	855.0	49.9	43.1	5	0	156
03/03/82	14:19:58	178.8	369.8	25.7	564.1	110.3	14.3	210.5	59	809.7	857.3	49.8	43.8	5	0	160
03/03/82	18:41:34	179.4	370.3	25.5	563.2	111.0	14.2	210.4	58	812.0	859.7	49.9	43.6	5	0	165
03/03/82	22:41:39	180.4	370.5	25.3	561.4	109.9	14.3	210.5	57	808.2	855.8	50.0	44.1	5	0	169
04/03/82	02:41:45	180.6	370.4	25.4	562.4	109.5	14.3	210.7	56	805.9	853.4	50.0	44.1	5	0	173

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Table C-8. Endurance Test Record, Part 2 of 10

Date	Time	P1 psia	T1 oF	&1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWh	Freq Hz	Eff %	IC	trk	file
04/03/82	06:41:49	180.3	369.2	25.5	562.7	109.4	14.4	211.0	56	805.7	853.3	50.0	44.2	5	0	177
04/03/82	10:41:54	178.1	369.9	25.8	565.2	109.7	14.3	210.7	58	805.9	853.4	49.9	43.8	5	0	181
04/03/82	14:59:36	179.8	373.0	26.2	569.1	108.4	14.5	211.3	57	805.7	853.2	50.0	43.8	5	0	185
04/03/82	18:59:43	180.8	373.4	26.8	574.1	109.2	14.5	211.2	56	811.9	859.6	49.9	43.0	5	0	189
04/03/82	22:59:48	181.6	371.5	26.0	567.9	108.1	14.4	210.7	55	805.6	853.2	50.0	43.8	5	0	193
05/03/82	02:59:53	181.5	371.4	25.9	567.2	108.4	14.6	210.3	54	804.4	852.0	50.1	44.0	5	0	197
05/03/82	06:59:59	181.3	371.7	25.9	566.8	108.0	14.6	210.6	54	804.7	852.2	50.1	44.2	5	0	201
05/03/82	10:00:03	180.3	369.8	26.0	567.3	107.5	14.4	211.0	55	802.4	850.0	49.9	44.1	5	0	204
05/03/82	14:58:57	177.1	371.7	26.6	571.5	107.9	14.5	211.3	59	8[illegible]7	855.3	49.8	44.0	5	0	208
05/03/82	18:23:23	177.8	372.1	26.4	570.2	108.4	14.4	211.1	59	809.1	856.7	49.7	43.9	5	0	211
05/03/82	22:23:29	180.2	373.1	26.7	573.5	109.1	14.5	211.5	56	812.0	859.8	49.9	43.3	5	0	215
06/03/82	02:23:35	180.9	370.8	25.9	567.1	108.8	14.7	211.9	54	805.3	852.9	49.9	44.0	5	0	219
06/03/82	06:23:[illegible]	181.6	370.9	25.8	566.2	107.6	14.4	210.5	54	804.2	851.7	50.0	44.2	5	0	22[illegible]
06/03/82	10:[illegible]:50	180.3	373.2	26.3	569.6	108.9	14.6	211.6	55	804.7	852.3	49.9	43.5	5	0	227
06/03/82	14:01:57	178.8	369.8	26.3	569.3	109.0	14.4	210.4	57	807.8	855.4	49.8	43.7	5	0	231
06/03/82	18:02:03	179.8	370.5	26.0	567.4	108.5	14.5	211.0	57	808.5	855.9	49.9	44.2	5	0	23[illegible]
06/03/82	22:02:1[illegible]	180.7	373.4	26.3	569.7	108.8	14.6	211.6	55	806.2	853.5	50.0	43.6	5	0	23[illegible]
07/03/82	02:02:14	181.1	373.6	26.[illegible]	568.1	108.5	14.5	211.3	55	805.6	852.9	50.0	43.[illegible]	5	0	24[illegible]
07/03/82	06:02:20	18[illegible].5	3[illegible]	2[illegible].7	565.6	108.5	14.5	211.8	54	804.3	851.6	50.0	44.2	5	[illegible]	[illegible]
07/03/82	10:02:26	179.6	372.9	26.4	570.4	108.4	14.5	211.4	56	806.5	854.0	49.9	43.7	5	0	25[illegible]
07/03/82	14:02:32	177.6	372.0	26.5	570.9	108.5	14.4	211.0	58	808.2	855.6	49.7	43.7	5	0	255
07/03/82	18:02:38	178.8	372.5	26.5	571.1	107.6	14.4	211.0	59	809.7	857.2	49.7	43.9	5	0	25[illegible]
07/03/82	22:02:4[illegible]	180.1	373.1	26.3	569.6	108.7	14.4	210.9	57	807.9	855.3	49.6	43.5	5	0	26[illegible]
08/03/82	02:10:04	180.1	370.6	26.1	568.4	108.4	14.5	211.6	56	806.1	853.6	49.9	43.9	5	0	26[illegible]
08/03/82	06:10:10	[illegible]9.9	373.0	26.5	571.2	107.4	14.5	211.4	56	805.0	852.5	49.9	43.9	5	0	27[illegible]
08/03/82	10:19:33	179.5	368.7	26.[illegible]	568.3	108.9	14.3	210.7	58	810.0	857.6	49.8	43.8	5	0	27[illegible]
08/03/82	14:19:39	177.4	371.9	26.7	572.3	108.3	14.3	210.8	59	809.7	857.2	49.7	43.6	5	0	27[illegible]
08/03/82	18:19:44	179.2	372.7	26.6	571.9	107.9	14.4	211.0	57	808.8	856.4	49.8	43.7	5	0	282
08/03/82	22:19:49	180.6	373.3	26.3	570.2	108.3	14.4	210.9	56	806.8	854.3	49.9	43.6	5	0	28[illegible]
09/03/82	02:19:55	180.4	373.2	26.3	569.7	108.6	14.3	210.8	56	811.6	859.2	49.8	43.7	5	1	6
09/03/82	06:20:[illegible]	180.4	373.2	26.5	572.0	107.5	14.5	211.2	55	806.3	853.9	49.9	43.8	5	1	1[illegible]
09/03/82	10:20:06	179.3	372.8	26.4	570.7	107.3	14.4	211.1	58	808.5	856.0	49.8	44.1	5	1	14
09/03/82	14:20:12	176.3	372.3	26.7	572.5	107.9	14.4	211.1	58	810.1	857.7	49.6	43.6	5	1	18
09/03/82	18:20:17	178.6	372.5	26.7	572.4	108.5	14.4	211.0	57	809.7	857.2	49.9	43.5	5	1	22
09/03/82	22:20:23	179.6	372.9	26.5	571.6	108.2	14.3	210.5	56	809.4	857.0	49.9	43.5	5	1	26
10/03/82	02:20:29	180.0	373.1	26.6	572.7	108.1	14.5	211.2	56	810.7	858.4	49.9	43.6	5	1	30
10/03/82	06:20:36	180.3	373.2	26.5	571.5	107.6	14.4	211.0	56	807.0	854.5	50.0	43.7	5	1	34
10/03/82	10:20:41	179.0	372.6	26.8	574.0	107.9	14.4	210.9	57	812.1	859.8	49.8	43.6	5	1	38
10/03/82	14:20:47	177.4	371.9	26.7	572.5	108.4	14.4	210.9	58	808.8	856.4	49.7	43.5	5	1	42
10/03/82	18:20:54	179.2	372.7	26.7	573.2	106.9	14.4	210.8	57	809.2	856.8	49.8	43.9	5	1	46
10/03/82	22:21:01	180.5	373.3	26.4	570.9	107.9	14.5	211.3	55	806.5	854.0	49.9	43.7	5	1	50
11/03/82	02:21:07	179.8	373.0	26.7	572.8	108.5	14.6	211.5	55	808.2	855.9	50.0	43.4	5	1	54

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Table C-8. Endurance Test Record, Part 3 of 10

Date	Time	P1 psia	T1 oF	Q: %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	I?	trk	File
11/03/82	06:21:14	180.4	373.2	26.6	572.1	107.3	14.5	211.3	55	804.8	852.3	50.0	43.8	5	1	58
11/03/82	10:21:19	178.5	372.4	26.9	574.0	106.8	14.5	211.4	58	807.1	854.6	49.8	44.0	5	1	62
11/03/82	14:21:24	178.3	372.3	26.9	574.3	108.1	14.5	211.2	58	809.2	856.8	49.8	43.5	5	1	66
11/03/82	18:21:31	178.8	372.5	26.7	572.4	107.9	14.5	211.3	56	808.4	856.0	49.9	43.8	5	1	70
11/03/82	22:21:38	179.9	373.0	26.7	573.1	107.4	14.5	211.4	56	808.3	855.9	50.0	43.9	5	1	74
12/03/82	02:21:44	180.2	373.1	26.5	571.2	107.6	14.6	211.7	55	807.2	854.8	50.0	44.0	5	1	78
12/03/82	06:21:50	180.5	373.3	26.6	572.5	107.8	14.5	211.3	55	807.2	854.8	50.0	43.6	5	1	82
12/03/82	10:21:56	179.2	372.7	26.9	574.2	108.2	14.7	211.9	57	808.0	855.6	49.9	43.5	5	1	86
12/03/82	14:22:00	178.6	372.4	26.7	572.6	107.6	14.5	211.3	58	809.5	857.1	49.8	43.9	5	1	90
12/03/82	18:22:05	179.0	372.6	26.7	572.7	107.8	14.5	211.3	56	809.1	856.7	49.8	43.8	5	1	94
12/03/82	22:22:11	180.0	373.1	26.6	572.3	107.1	14.6	211.6	55	808.1	855.7	50.0	44.1	5	1	98
13/03/82	02:22:15	180.4	373.3	26.6	572.5	107.9	14.6	211.8	55	806.8	854.4	50.0	43.7	5	1	102
13/03/82	06:22:22	180.4	373.2	26.7	573.2	106.9	14.6	211.6	55	806.6	854.2	50.0	44.0	5	1	106
13/03/82	10:22:28	179.1	372.6	26.9	574.1	107.2	14.6	211.5	56	808.6	856.2	49.9	43.9	5	1	[illegible]
13/03/82	14:22:33	178.6	372.4	26.7	572.7	107.3	14.5	211.4	57	810.2	857.9	49.8	44.1	5	1	114
13/03/82	18:22:38	179.4	372.8	26.6	573.5	107.1	14.5	211.4	56	809.9	857.5	49.9	44.3	5	1	118
13/03/82	22:22:43	180.6	373.3	26.5	571.6	106.7	14.7	212.1	55	807.6	855.2	50.0	44.5	5	1	[illegible]
14/03/82	02:22:46	180.[illegible]	373.1	26.5	571.6	107.2	14.5	211.4	54	806.9	854.5	50.0	44.[illegible]	5	1	[illegible]
14/03/82	06:22:53	17[illegible]	37[illegible]	26.[illegible]	574.1	10[illegible]	14.5	211.4	54	807.8	855.4	50.0	44.1	5	[illegible]	1[illegible]
14/03/82	10:22:57	17[illegible]	372.9	26.7	573.5	106.7	14.4	211.1	55	807.8	855.3	49.9	43.9	5	1	[illegible]
14/03/82	14:23:02	178.0	372.1	26.8	573.0	107.2	14.4	211.0	57	808.7	856.3	49.8	43.9	5	1	13[illegible]
14/03/82	18:23:08	179.7	372.9	26.5	571.5	107.2	14.4	211.[illegible]	56	808.[illegible]	855.7	49.9	44.[illegible]	5	[illegible]	14[illegible]
14/03/82	22:23:14	180.4	373.3	26.6	572.5	107.3	14.3	210.5	54	805.9	853.5	50.0	43.9	5	1	14[illegible]
15/03/82	02:23:22	180.3	373.2	26.6	572.3	107.3	14.4	211.1	53	804.6	852.1	50.0	43.7	5	1	15[illegible]
15/03/82	06:23:27	179.6	372.9	26.7	572.7	107.4	14.5	211.3	54	807.8	855.5	50.0	43.8	5	1	154
15/03/82	10:23:33	179.0	372.6	26.9	574.9	106.4	14.4	211.0	56	807.0	854.6	49.9	43.5	5	1	15[illegible]
15/03/82	14:23:37	177.2	371.8	26.8	573.2	107.8	14.4	210.9	58	810.1	857.8	49.8	43.8	5	1	16[illegible]
15/03/82	18:23:42	178.3	372.3	26.9	570.7	108.2	14.4	211.0	56	809.2	856.6	49.9	43.9	[illegible]	1	16[illegible]
15/03/82	22:23:43	179.6	373.0	26.5	571.3	107.2	14.3	210.8	54	807.9	855.5	49.9	43.9	5	1	17[illegible]
16/03/82	02:23:53	179.5	372.9	26.5	573.5	106.7	14.3	210.3	53	804.9	852.5	50.0	43.7	5	1	174
16/03/82	06:24:00	179.9	373.[illegible]	26.[illegible]	569.9	107.0	14.3	210.7	54	805.3	852.9	50.0	44.0	5	1	178
16/03/82	10:24:08	178.5	372.4	26.8	573.1	106.7	14.3	210.5	56	805.3	852.8	49.9	43.7	5	1	182
16/03/82	14:36:33	179.5	370.5	26.4	570.4	106.4	14.4	210.6	55	807.1	854.7	50.0	44.5	5	1	185
16/03/82	18:38:38	179.6	370.7	26.3	569.6	107.2	14.3	210.5	54	806.8	854.4	50.0	44.1	5	1	18[illegible]
16/03/82	22:38:44	180.1	370.8	26.2	568.6	106.1	14.4	210.7	54	805.4	852.9	50.0	44.7	5	1	193
17/03/82	02:38:50	180.2	371.0	26.2	568.8	106.7	14.4	210.8	53	803.9	851.5	50.1	44.4	5	1	197
17/03/82	06:38:55	180.5	371.1	26.1	568.7	106.7	14.5	211.0	53	802.9	850.4	50.1	44.4	5	1	201
17/03/82	10:39:01	179.4	370.3	26.2	568.4	106.6	14.6	211.1	55	807.7	855.3	50.0	44.9	5	1	205
17/03/82	14:39:07	177.7	369.3	26.7	572.1	106.8	14.5	211.1	57	806.7	854.3	49.9	44.3	5	1	209
17/03/82	18:39:12	179.4	370.5	26.2	568.7	106.6	14.5	211.1	55	806.6	854.3	50.0	44.6	5	1	213
17/03/82	22:39:18	180.4	370.9	26.3	569.5	106.3	14.6	211.3	53	803.7	851.3	50.1	44.5	5	1	217
18/03/82	02:39:22	180.9	371.1	26.1	568.1	106.7	14.5	211.4	53	802.0	849.5	50.1	44.4	5	1	221

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Table C-8. Endurance Test Record, Part 4 of 10

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	kWe	KWM	Freq Hz	Eff %	DC	trk	file
18/03/82	06:39:29	180.2	371.1	26.3	569.5	107.1	14.6	211.5	53	801.5	849.1	50.1	44.1	5	1	225
18/03/82	10:39:36	177.7	369.5	26.4	569.7	107.7	14.5	211.5	57	807.9	855.5	49.9	44.3	5	1	229
18/03/82	14:39:43	178.0	369.4	26.7	572.0	106.2	14.7	211.4	57	806.4	854.0	49.9	44.7	5	1	233
18/03/82	18:39:49	179.2	370.3	26.3	569.9	106.9	14.5	211.4	56	806.8	854.4	49.9	44.4	5	1	237
18/03/82	22:39:55	180.1	370.8	26.4	570.3	106.1	14.5	211.4	54	804.5	852.1	50.0	44.5	5	1	241
19/03/82	02:40:01	180.3	370.9	26.3	570.1	106.7	14.6	211.4	54	803.2	850.7	50.0	44.4	5	1	245
19/03/82	06:40:08	180.0	370.8	26.3	569.8	105.8	14.6	211.4	54	803.7	851.3	50.0	44.8	5	1	249
19/03/82	10:35:35	179.0	369.2	26.6	571.9	106.0	14.6	211.4	55	805.4	853.0	49.9	44.6	5	1	254
19/03/82	14:20:41	178.2	369.5	26.6	571.9	107.2	14.6	211.2	56	807.8	855.4	49.8	44.2	5	1	259
19/03/82	18:05:48	178.7	370.2	26.6	572.0	106.3	14.5	211.2	56	809.3	857.0	49.9	44.5	5	1	264
19/03/82	22:35:57	179.9	370.3	26.5	571.2	105.9	14.5	211.1	55	807.6	855.2	49.9	44.6	5	1	270
20/03/82	02:21:02	179.8	369 3	26.4	570.3	106.1	14.5	211.1	54	806.3	853.9	50.0	44.6	5	1	275
20/03/82	06:06:09	179.8	369.2	26 4	570.6	107.0	14.4	211.0	54	809.5	857.2	50.0	44.2	5	1	[illegible]
20/03/82	10:23.45	176.7	366 7	26 4	570.3	106.7	14.5	211.0	55	807.7	855.3	49.9	44.5	6	[illegible]	[illegible]
21/03/82	07:4[illegible]	[illegible]	368.8	26.4	570 1	106.4	14.5	211.0	55	807.4	855.0	49 9	44.[illegible]	[illegible]	[illegible]	[illegible]
21/03/82	11.14 26	176 2	368.[illegible]	26 8	573.[illegible]	106.1	14.5	210.9	56	807.6	855 4	49.9	44 4	6	[illegible]	[illegible]
21/03/82	15.14:32	176.5	369 1	26 4	569.3	107.4	14.4	210 8	56	809.0	856.6	49.7	44.4	6	[illegible]	[illegible]
21/03/82	19.14:37	179 0	370 5	26 0	566 9	107.2	14 3	211.0	55	808.1	855.7	49.5	44.5	6	[illegible]	[illegible]
21/03/82	23:14.43	18[illegible].4	370 9	[illegible]	567.6	107.3	14.5	211.2	55	810.1	857.8	49.9	44.[illegible]	6	[illegible]	[illegible]
22/03/82	03:14.48	180 3	371.0	26.1	567.8	106.9	14.5	211.3	53	805.3	852.9	50.0	44.5	6	[illegible]	[illegible]
22/03/82	07:14:54	180 0	371.[illegible]	26 1	567.9	106.8	14.5	211.4	53	803.9	851.4	50.1	44.6	6	[illegible]	[illegible]
22/03/82	11:15:00	177.7	369 5	26.3	569.0	107.1	14 5	211.4	57	807.8	855 4	49 8	44.7	6	[illegible]	[illegible]
22/03/82	15:15:07	176.7	369.1	26.5	569.9	106.5	14.6	211.2	58	809.8	857.4	49.7	45.1	6	[illegible]	[illegible]
22/03/82	19:15·14	179 4	370.3	26.2	569.2	106 0	14 5	211.2	55	807.8	855.4	49.8	45.0	6	[illegible]	[illegible]
22/03/82	23:15:19	180 1	370 6	26.1	566 2	106.8	14.6	211.4	55	806.2	853 8	49.9	44.7	6	[illegible]	[illegible]
23/03/82	03:15·25	179 7	370.6	26 2	568.8	107.1	14.6	211.4	55	806.8	856.5	49.9	44.7	6	[illegible]	[illegible]
23/03/82	07:15:32	180.0	370.7	26.1	567.7	106.8	14.5	211.4	54	804.1	851.6	49.9	44.5	6	[illegible]	[illegible]
23/03/82	11.15·37	179 1	370.3	26 1	566 0	107.3	14.6	211.4	55	807.1	854.7	49.8	44.6	6	[illegible]	[illegible]
23/03/82	15·15:42	179.3	370.2	26.2	568.5	107.3	14.5	211.3	56	808.3	855.9	49.8	44.5	6	[illegible]	[illegible]
23/03/82	19·15 46	179 6	370 5	26 1	566.0	107.9	14.5	211.3	56	812.5	860.2	49.6	44.6	6	0	[illegible]
23/03/82	23:15:52	179.6	370.6	26.2	568 4	107.4	14.5	211.3	54	807.6	855.2	49.9	44.4	6	0	[illegible]
24/03/82	03:15:56	180.2	370.6	26.1	567.6	106.8	14.4	211.2	55	805.9	853.4	49.9	44.5	6	0	76
24/03/82	07:16:01	179.6	370.5	26.1	568.1	107.0	14.4	211.2	56	809.8	857.5	49.8	44.7	6	0	80
24/03/82	11:16:06	179.4	370.4	26.1	567.6	107.2	14.6	211.2	55	807.4	855.0	49.8	44.7	6	0	84
24/03/82	15:16:13	179.6	370.5	26.1	568.1	106.3	14.4	211.1	56	807.7	855.3	49.8	44.6	6	0	88
24/03/82	19:16:20	179.8	370.5	26.2	569.0	106.6	14.5	211.0	55	807.4	855.0	49.9	44.6	6	0	92
24/03/82	23:16:25	180.4	370.7	26.3	570.2	106.8	14.4	211.0	54	807.0	854.6	49.9	44.2	6	0	96
25/03/82	03:16:30	179.6	370.6	26.0	567.0	107.5	14.4	210.9	55	811.6	859.4	49.9	44.7	6	0	100
25/03/82	07:16:37	180.3	370.7	26.1	568.2	107.0	14.4	210.9	54	805.8	853.4	49.9	44.4	6	0	104
25/03/82	11·16:41	179.4	370.3	26.2	568.5	106.7	14.4	210.8	55	808.1	855.8	49.8	44.6	6	0	108
25/03/82	15:16:45	178.9	370.3	26.2	568.8	107.3	14.3	210.7	55	807.4	855.0	49.8	44.2	6	0	112
25/03/82	19:16:51	180.2	370.9	26.1	568.4	106 9	14.3	210.7	53	807.4	855.0	50.0	44.4	6	0	116

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Table C-8. Endurance Test Record, Part 5 of 10

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWH	Freq Hz	Eff %	DC	trk	file
25/03/82	23:16:58	180.1	371.0	25.9	566.5	106.6	14.4	210.9	53	805.8	853.4	50.0	44.8	6	0	120
26/03/82	03:17:05	180.3	371.1	26.0	567.7	106.4	14.4	210.9	53	804.6	852.2	50.0	44.7	6	0	124
26/03/82	07:17:11	180.1	371.1	26.1	568.0	106.4	14.3	210.9	52	802.6	850.1	50.0	44.4	6	0	128
26/03/82	11:17:16	178.8	370.2	26.4	570.4	106.1	14.4	210.9	54	805.2	852.7	49.9	44.5	6	0	132
26/03/82	15:17:20	178.1	370.0	26.3	569.2	107.6	14.4	210.8	55	806.8	854.4	49.8	44.3	6	0	136
26/03/82	19:17:26	179.6	370.8	26.1	567.7	106.5	14.4	210.8	53	807.3	854.9	49.9	44.8	6	0	140
26/03/82	23:17:32	180.4	371.1	26.0	567.7	105.9	14.4	210.8	52	804.1	851.7	50.0	44.7	6	0	144
27/03/82	03:17:38	180.2	371.1	26.1	568.3	105.8	14.3	210.7	52	803.0	850.6	50.0	44.6	6	0	148
27/03/82	07:17:44	180.1	371.1	26.0	567.7	106.4	14.3	210.7	52	803.6	851.1	50.0	44.4	6	0	152
27/03/82	11:17:49	178.6	370.0	26.4	570.0	106.1	14.3	210.7	56	809.7	857.4	49.9	44.7	6	0	156
27/03/82	15:17:55	178.9	370.4	26.2	568.5	106.4	14.4	210.6	54	807.8	855.4	49.9	44.8	6	0	160
27/03/82	19:18:02	179.4	370.6	26.2	568.3	106.2	14.3	210.6	54	806.0	853.6	49.9	44.6	6	0	164
27/03/82	23:18:08	179.7	370.8	26.3	569.6	105.3	14.3	210.6	53	804.9	852.5	50.0	44.8	6	0	168
28/03/82	03:18:12	179.8	370.9	26.2	568.6	105.9	14.3	210.6	53	804.7	852.2	50.0	44.6	6	0	172
28/03/82	07:18:16	179.7	370.8	26.2	568.8	105.9	14.3	210.6	53	804.6	852.1	49.9	44.6	6	0	176
28/03/82	11:18:22	180.4	370.9	26.1	568.7	106.4	14.4	210.7	53	807.1	854.7	50.0	44.5	6	0	180
28/03/82	15:18:27	179.6	370.6	26.3	568.5	106.9	14.4	210.6	55	811.1	858.8	49.9	44.7	6	0	184
28/03/82	19:18:33	180.3	370.9	25.9	568.1	106.3	14.4	210.7	53	806.4	854.0	49.9	44.6	6	0	188
28/03/82	23:18:39	180.4	371.2	26.0	567.4	105.9	14.3	210.7	53	805.3	852.8	50.0	44.8	6	0	192
29/03/82	03:18:45	180.2	371.1	26.3	568.6	106.1	14.3	210.7	53	806.2	855.8	49.9	44.6	6	0	196
29/03/82	07:18:51	180.4	371.1	26.2	568.9	105.7	14.2	210.7	52	804.3	851.8	50.0	44.5	6	0	200
29/03/82	11:18:57	179.1	370.5	26.4	570.7	105.3	14.3	210.7	54	806.0	853.6	49.9	44.7	6	0	204
29/03/82	15:19:02	178.8	370.4	26.3	569.4	105.7	14.3	210.6	53	806.0	853.6	49.9	44.7	6	0	208
29/03/82	19:19:09	179.6	370.6	26.1	568.3	106.9	14.4	210.6	53	807.3	854.9	50.0	44.5	6	0	212
29/03/82	23:19:14	180.0	371.1	26.3	569.4	105.5	14.3	210.7	52	805.1	852.6	50.0	44.6	6	0	216
30/03/82	03:19:17	179.9	371.1	26.2	566.9	105.9	14.3	210.7	52	805.2	852.7	50.0	44.6	6	0	220
30/03/82	07:19:24	180.6	371.2	26.0	567.8	106.3	14.4	210.9	52	804.3	851.8	50.0	44.6	6	0	224
30/03/82	11:19:31	179.1	370.9	26.3	569.7	105.7	14.4	211.0	53	804.5	852.0	50.0	44.7	6	0	228
30/03/82	15:19:38	177.9	370.0	26.2	568.3	106.4	14.4	211.0	55	806.7	854.3	49.9	44.9	6	0	232
30/03/82	19:19:44	180.1	371.0	26.2	568.9	105.8	14.5	211.1	52	805.5	853.0	50.0	44.9	6	0	236
30/03/82	23:19:51	180.7	371.3	25.9	566.9	106.4	14.3	211.3	51	802.7	850.2	50.1	44.5	6	0	240
31/03/82	03:19:56	181.1	371.3	26.5	571.7	107.6	14.5	211.3	51	805.3	852.9	50.1	43.6	6	0	244
31/03/82	07:20:01	180.7	371.2	26.6	573.0	106.3	14.4	211.4	51	801.7	849.2	50.1	43.8	6	0	248
31/03/82	11:20:06	177.2	369.6	26.9	573.8	105.7	14.5	211.3	56	804.5	852.0	49.9	44.4	6	0	252
31/03/82	15:06:39	177.3	369.5	26.6	571.1	106.9	14.5	211.2	57	807.4	855.0	49.8	44.4	6	0	256
31/03/82	19:06:44	178.7	370.2	26.5	570.8	106.1	14.4	211.2	54	806.4	854.0	49.9	44.6	6	0	260
31/03/82	23:06:48	179.5	370.5	26.3	569.8	105.6	14.4	211.2	53	805.7	853.3	50.0	44.8	6	0	264
01/04/82	03:06:53	179.5	370.6	26.4	570.2	105.1	14.4	211.2	53	805.2	852.7	50.0	44.9	6	0	268
01/04/82	07:06:58	179.2	370.6	26.3	569.1	105.2	14.6	211.2	52	804.2	851.7	50.0	45.2	6	0	272
01/04/82	11:07:05	178.9	370.2	26.2	568.7	106.6	14.5	211.2	54	805.9	853.5	49.9	44.7	6	0	276
01/04/82	15:07:12	178.6	370.0	26.4	570.3	106.1	14.5	211.0	55	807.4	855.0	49.9	44.7	6	0	280
01/04/82	19:07:16	178.5	370.2	26.4	569.8	195.6	14.4	211.0	55	808.4	856.0	49.9	45.0	6	0	284

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Table C-8. Endurance Test Record, Part 6 of 10

Date	Time	P1 psia	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWM	Freq Hz	Eff %	DC	trk	file
01/04/82	23:07:22	179.6	370.5	26.0	567.2	105.6	14.5	211.0	54	806.3	853.9	49.9	45.2	6	1	4
02/04/82	03:07:29	179.1	370.4	26.3	569.2	106.4	14.5	210.9	53	807.4	855.0	49.9	44.6	6	1	8
02/04/82	07:07:36	180.0	370.6	26.4	570.3	105.2	14.4	210.9	53	805.9	853.5	50.0	44.6	6	1	12
02/04/82	11:07:43	178.0	370.0	26.6	571.5	105.0	14.4	211.0	54	805.8	853.4	49.9	44.9	6	1	16
02/04/82	15:07:50	177.8	369.6	26.5	570.7	105.3	14.4	210.9	56	808.4	856.0	49.8	45.1	6	1	20
02/04/82	19:07:56	179.2	370.4	26.3	569.3	105.8	14.4	210.9	54	807.7	855.3	49.9	44.8	6	1	24
02/04/82	23:08:02	179.0	370.4	26.3	569.2	105.6	14.3	210.9	55	810.8	858.5	49.9	45.0	6	1	28
03/04/82	03:08:09	179.2	370.7	26.4	570.3	105.0	14.4	210.8	53	806.4	853.9	49.9	45.0	6	1	32
03/04/82	07:08:15	179.4	370.6	26.1	567.9	105.2	14.4	210.8	53	806.5	854.1	49.9	45.2	6	1	36
03/04/82	11:08:21	178.6	370.5	26.3	569.4	105.5	14.4	210.8	53	808.5	856.1	49.9	45.1	6	1	40
03/04/82	15:08:26	178.0	370.3	26.3	569.3	105.2	14.3	210.7	53	805.8	853.4	49.9	45.0	6	1	44
03/04/82	19:08:31	179.5	370.9	26.0	567.2	105.8	14.3	210.8	52	805.2	852.8	50.0	44.9	6	1	48
03/04/82	23:08:36	180.0	371.1	25.9	566.3	105.9	14.3	210.9	52	803.8	851.3	50.0	44.9	6	1	52
04/04/82	03:08:42	180.1	371.0	25.9	566.9	105.6	14.5	210.9	51	803.1	850.6	50.0	45.1	6	1	56
04/04/82	07:08:49	179.9	371.0	26.[illegible]	567.7	105.4	14.4	211.0	52	805.0	852.6	50.0	45.1	6	1	60
04/04/82	11:08:55	18[illegible]	370.8	26.1	568.0	106.3	14.4	211.1	52	802.9	850.4	50.0	44.6	6	1	6[illegible]
04/04/82	15:09:02	179.8	37[illegible]	26.2	569.5	104.9	14.3	211.1	52	804.1	851.6	50.0	45.2	6	1	[illegible]
04/04/82	19:09:10	18[illegible]	370.9	25.9	565.8	106.0	14.5	211.1	53	807.4	855.0	50.0	45.2	6	1	[illegible]
04/04/82	23:09:17	18[illegible]	371.3	25.9	566.3	10[illegible]	14.6	211.2	51	803.2	850.7	50.0	45.1	6	1	76
05/04/82	03:09:21	18[illegible]	371.4	25.6	566.2	105.1	14.3	211.2	51	802.6	850.4	50.0	44.8	6	1	8[illegible]
05/04/82	07:09:2[illegible]	181.1	371.4	25.9	566.7	105.9	14.4	211.2	51	803.1	850.7	50.1	44.9	6	1	84
05/04/82	11:09:31	177.9	370.[illegible]	26.3	568.9	106.4	14.4	211.3	55	804.6	852.[illegible]	49.9	44.7	6	1	[illegible]
05/04/82	15:09:36	178.2	370.[illegible]	26.4	570.4	105.7	14.6	211.3	54	805.4	853.0	49.9	44.9	6	1	92
05/04/82	19:09:43	179.8	370.7	26.0	567.0	106.6	14.5	211.3	53	808.3	856.0	50.0	45.0	6	1	9[illegible]
05/04/82	23:09:49	180.3	371.1	26.0	567.5	105.2	14.5	211.4	51	803.6	851.2	50.0	45.2	6	1	1[illegible]
06/04/82	03:09:55	180.4	371.0	26.0	567.5	105.7	14.5	211.4	51	806.1	853.7	50.1	45.1	6	1	104
06/04/82	07:09:59	179.5	371.1	26.0	566.7	105.5	14.6	211.5	51	801.6	849.2	50.1	45.3	6	1	10[illegible]
06/04/82	11:10:05	179.4	370.2	26.3	569.5	105.5	14.6	211.4	53	803.0	850.5	49.9	44.9	6	1	112
06/04/82	15:10:11	176.9	370.2	26.2	568.3	106.1	14.6	211.3	54	806.9	854.5	49.9	45.1	6	1	11[illegible]
06/04/82	19:10:16	179.6	370.7	26.1	568.2	105.8	14.5	211.3	52	805.3	852.9	50.0	45.0	6	1	12[illegible]
06/04/82	23:10:20	180.2	370.7	26.1	567.8	106.1	14.3	211.3	52	806.9	854.5	50.0	44.6	6	1	124
07/04/82	03:10:23	180.1	371.0	26.1	567.6	105.0	14.5	211.3	52	803.7	851.2	50.0	45.3	6	1	12[illegible]
07/04/82	07:59:33	180.0	370.9	26.2	569.2	104.9	14.4	211.2	51	803.9	851.4	50.0	45.0	6	1	131
07/04/82	11:59:38	179.5	370.5	26.1	567.8	105.8	14.5	211.2	53	805.4	853.0	49.9	45.1	6	1	135
07/04/82	15:59:44	179.8	370.6	26.3	569.8	104.4	14.4	211.1	53	805.7	853.3	50.0	45.3	6	1	139
07/04/82	19:59:49	180.0	370.7	26.2	568.7	105.6	14.5	211.1	53	805.2	852.8	50.0	44.9	6	1	143
07/04/82	23:59:54	180.8	370.9	26.3	569.7	105.3	14.4	211.1	51	805.1	852.7	50.0	44.8	6	1	147
08/04/82	04:00:00	179.8	371.0	26.3	570.1	104.6	14.5	211.0	52	805.3	852.9	50.0	45.2	6	1	151
08/04/82	08:00:06	180.4	370.8	26.2	568.9	105.5	14.4	211.1	51	804.9	852.5	50.0	44.9	6	1	155
08/04/82	12:00:11	180.6	371.0	26.2	569.4	104.7	14.4	211.1	52	807.0	854.6	49.9	45.2	6	1	159
08/04/82	16:00:16	181.3	370.9	26.1	568.4	105.0	14.5	211.0	52	808.6	856.3	50.0	45.4	6	1	163
08/04/82	20:00:22	180.3	370.9	26.1	568.4	105.4	14.4	211.0	52	806.7	854.3	49.9	45.1	6	1	167

Table C-8. Endurance Test Record, Part 7 of 10

Date	Time	P1 psia	T1 °F	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 °F	Tr %	KWe	KWH	Freq Hz	Eff %	DC	trk	file
09/04/82	00:00:27	179.8	370.9	26.2	569.1	104.6	14.5	211.0	52	805.5	853.0	50.0	45.3	6	1	171
09/04/82	04:00:33	180.4	371.1	26.2	568.9	105.0	14.4	210.9	51	805.6	853.1	50.0	45.1	6	1	175
09/04/82	08:00:39	180.4	371.3	26.5	571.4	104.0	14.4	211.0	50	804.0	851.5	50.0	45.0	6	1	179
09/04/82	12:00:45	180.3	370.7	26.4	570.7	104.9	14.5	211.0	51	805.9	853.5	50.0	45.0	6	1	183
09/04/82	16:00:51	178.8	370.0	26.3	569.8	105.3	14.3	211.0	53	805.3	852.9	50.0	44.9	6	1	187
09/04/82	20:00:56	180.0	371.1	26.3	569.7	104.0	14.4	211.0	52	804.6	852.2	50.0	45.4	6	1	191
10/04/82	00:01:02	180.4	371.3	26.0	567.3	105.5	14.5	211.1	51	804.2	851.8	50.1	45.1	6	1	195
10/04/82	04:01:07	180.8	371.3	25.9	566.4	105.3	14.4	211.1	50	804.1	851.7	50.1	45.2	6	1	199
10/04/82	08:01:13	181.0	371.2	26.3	570.5	104.7	14.5	211.3	50	803.7	851.3	50.1	45.0	6	1	203
10/04/82	12:01:20	181.1	371.0	26.1	568.4	104.8	14.5	211.4	51	803.3	850.9	50.0	45.2	6	1	207
10/04/82	16:01:26	179.8	370.8	26.1	568.3	105.1	14.6	211.4	52	804.5	852.1	50.0	45.4	6	1	211
10/04/82	20:01:32	181.7	371.6	26.2	569.9	104.1	14.5	211.5	50	803.4	850.9	50.0	45.2	6	1	215
11/04/82	00:01:38	179.9	371.3	26.1	568.5	103.9	14.8	211.6	51	802.4	849.9	50.1	46.0	6	1	219
11/04/82	04:01:43	180.5	371.3	26.2	568.9	104.9	14.5	211.7	51	801.7	849.4	50.1	45.0	6	1	223
11/04/82	08:01:48	179.[illegible]	370.6	26.4	570.4	104.9	14.6	211.8	52	802.6	850.1	50.0	45.1	6	1	227
11/04/82	12:01:53	177.3	369.6	26.5	574.1	103.8	14.7	211.7	55	805.6	852.5	49.9	45.4	6	1	231
11/04/82	16:02:00	175.9	368.7	26.6	572.4	104.4	14.6	211.6	57	806.6	854.2	49.8	45.5	6	1	235
11/04/82	20:02:06	179.3	370.0	26.3	571.4	104.1	14.6	211.6	53	803.9	851.5	50.0	45.4	6	1	239
12/04/82	00:02:12	179.0	370.1	26.4	571.2	104.5	14.6	211.7	52	802.4	850.0	50.1	45.3	6	1	243
12/04/82	04:02:18	179.3	370.4	26.5	571.7	103.8	14.6	211.7	52	801.7	849.3	50.1	45.3	6	1	24
12/04/82	08:02:24	179.2	370.1	26.4	570.8	104.6	14.6	211.8	52	802.9	850.5	50.1	45.2	6	1	251
12/04/82	12:02:30	175.7	368.8	26.7	571.4	103.5	14.6	211.7	57	802.5	850.1	49.8	45.8	6	1	255
12/04/82	16:02:35	175.9	369.1	[illegible]	570.6	104.4	14.5	211.5	56	805.2	852.8	49.8	45.5	6	1	259
12/04/82	20:02:40	176.7	370.4	26.5	571.0	104.4	14.5	211.5	52	803.7	851.3	50.0	45.2	6	1	263
13/04/82	00:02:44	179.1	370.6	26.4	570.3	103.9	14.6	211.6	51	802.2	849.6	50.1	45.5	6	1	267
13/04/82	04:02:48	178.9	370.3	26.4	569.9	104.1	14.6	211.5	51	803.0	850.5	50.1	45.6	6	1	271
13/04/82	08:02:54	178.3	370.0	26.3	571.0	103.4	14.5	211.5	52	802.2	849.7	50.0	45.6	6	1	275
13/04/82	12:03:00	177.7	369.6	26.5	570.2	103.6	14.6	211.4	54	803.2	850.7	50.0	45.8	6	1	279
13/04/82	16:03:05	176.1	368.9	26.6	571.3	104.2	14.5	211.3	56	805.9	853.5	49.9	45.6	6	1	283
13/04/82	20:03:11	175.5	370.0	26.3	568.6	104.2	14.6	211.3	53	804.4	852.0	50.0	45.6	6	1	28
14/04/82	00:03:54	178.6	370.0	26.1	567.1	105.4	14.6	211.3	52	803.8	851.3	50.0	45.5	7	0	8
14/04/82	04:04:02	179.9	370.7	25.8	565.4	105.0	14.6	211.2	51	803.0	850.5	50.0	45.7	7	0	12
14/04/82	08:04:07	178.6	370.0	26.2	568.4	104.9	14.5	211.2	52	803.1	850.7	50.0	45.3	7	0	16
14/04/82	12:04:14	177.4	369.5	26.5	570.6	104.4	14.4	211.2	54	805.1	852.6	49.9	45.3	7	0	20
14/04/82	16:04:20	177.2	369.3	26.3	568.7	104.9	14.5	211.1	56	806.6	854.2	49.9	45.5	7	0	24
14/04/82	20:04:25	177.5	369.7	26.2	567.9	104.9	14.4	211.1	53	806.1	853.7	49.9	45.6	7	0	28
15/04/82	00:04:29	177.4	369.4	26.2	568.1	105.2	14.4	211.0	56	809.2	856.9	49.9	45.5	7	0	32
15/04/82	04:04:33	176.9	369.4	26.2	567.9	105.3	14.4	210.9	55	809.5	857.2	49.9	45.6	7	0	36
15/04/82	08:04:40	177.2	369.4	26.2	568.1	105.1	14.4	210.9	55	809.3	857.0	49.8	45.6	7	0	40
15/04/82	12:04:44	176.4	369.1	26.2	567.7	104.4	14.4	210.8	56	807.2	854.8	49.8	45.8	7	0	44
15/04/82	16:04:50	178.4	369.9	26.1	567.6	105.0	14.3	210.6	53	807.5	855.1	50.0	45.4	7	0	48
15/04/82	20:04:56	178.1	369.6	26.1	567.8	105.1	14.3	210.6	54	810.6	858.3	50.2	45.5	7	0	52

Table C-8. Endurance Test Record, Part 8 of 10

Date	Time	Pi psia	Ti oF	Qi %	H btu/lb	Mi klb/h	P2 psia	T2 oF	Tr %	KWe	KWH	Freq Hz	Eff %	DC	trk	file
16/04/82	00:05:03	178.6	370.1	26.3	569.0	104.7	14.4	210.7	52	806.9	854.6	50.2	45.4	7	0	56
16/04/82	04:05:09	179.3	370.4	26.3	569.4	104.0	14.3	210.8	51	804.5	852.0	50.2	45.3	7	0	60
16/04/82	08:05:15	178.8	370.3	26.3	569.0	104.0	14.4	211.0	52	804.0	851.5	50.1	45.5	7	0	64
16/04/82	12:05:20	177.9	369.4	26.3	569.2	105.1	14.5	211.1	54	805.5	853.1	49.9	45.3	7	0	68
16/04/82	16:05:25	177.5	369.4	26.3	569.1	104.7	14.4	211.1	54	806.9	854.5	49.9	45.5	7	0	72
16/04/82	20:05:30	178.3	369.8	26.2	568.5	104.4	14.5	211.2	53	804.7	852.3	49.9	45.7	7	0	76
17/04/82	00:05:35	178.4	369.9	26.4	570.3	104.3	14.5	211.2	52	804.0	851.5	50.0	45.3	7	0	80
17/04/82	04:05:41	179.0	370.5	26.3	569.4	104.0	14.5	211.2	51	803.6	851.1	50.0	45.5	7	0	84
17/04/82	08:05:48	177.9	369.8	26.5	570.4	104.0	14.5	211.3	53	804.9	852.4	49.9	45.6	7	0	88
17/04/82	12:05:52	176.9	369.1	26.5	570.0	104.8	14.7	211.3	55	806.1	853.7	49.9	45.7	7	0	92
17/04/82	16:06:00	177.4	369.4	26.3	568.7	104.9	14.6	211.3	56	807.5	855.1	49.8	45.7	7	0	96
17/04/82	20:06:06	177.7	369.7	26.6	571.4	104.8	14.6	211.3	53	806.1	853.6	49.9	45.3	7	0	100
18/04/82	00:06:11	177.6	369.6	26.4	570.0	104.3	14.6	211.4	54	807.5	855.1	49.9	45.8	7	0	104
18/04/82	04:06:19	177.7	370.1	26.3	569.3	103.9	14.4	211.4	52	803.3	850.8	49.9	45.6	7	0	108
18/04/82	08:06:24	179.2	370.4	26.3	569.3	103.8	14.6	211.5	51	803.3	850.9	50.0	45.8	7	0	112
18/04/82	12:06:30	176.1	369.0	26.8	572.6	103.7	14.6	211.4	56	806.1	853.7	49.8	45.7	7	0	116
18/04/82	16:06:36	178.4	369.9	26.5	571.0	104.0	14.5	211.4	53	807.8	855.5	49.9	45.6	7	0	120
18/04/82	20:06:44	177.9	369.6	26.5	570.4	103.5	14.5	211.4	53	806.6	854.2	49.9	45.9	7	0	124
19/04/82	00:06.49	178.4	369.9	26.4	570.1	104.0	14.5	211.4	53	804.6	852.2	49.9	45.5	7	0	128
19/04/82	04:06:54	178.8	370.1	26.5	570.8	104.1	14.5	211.3	51	805.1	852.7	50.0	45.5	7	0	132
19/04/82	08:06:59	178.5	370.0	26.6	572.0	103.4	14.5	211.4	52	806.4	854.0	49.9	45.7	7	0	136
19/04/82	12:07:06	179.0	370.2	26.6	571.8	102.9	14.5	211.3	52	804.6	852.1	49.9	45.7	7	0	140
19/04/82	16:07:12	178.5	370.1	26.4	570.4	103.4	14.6	211.1	52	804.4	852.0	49.9	45.9	7	0	144
19/04/82	20:07:17	178.7	370.2	26.5	570.8	103.1	14.5	211.1	52	804.7	852.2	49.9	45.8	7	0	148
20/04/82	00:07:22	178.6	370.1	26.6	571.7	103.3	14.4	211.1	51	804.3	851.8	49.9	45.5	7	0	152
20/04/82	04:07:28	178.8	370.1	26.4	570.2	103.4	14.4	211.0	52	805.2	852.7	49.9	45.7	7	0	156
20/04/82	08:07:35	178.5	369.9	26.5	570.9	103.6	14.5	211.1	52	804.1	851.7	49.9	45.5	7	0	160
20/04/82	12:07:40	177.8	369.5	26.7	572.1	104.5	14.4	211.1	54	810.7	858.4	49.8	45.4	7	0	164
20/04/82	16:07:45	178.1	369.7	26.6	571.8	103.7	14.4	211.0	54	810.2	857.9	50.0	45.6	7	0	168
20/04/82	20:07:51	178.4	369.9	26.6	572.0	103.2	14.4	211.0	52	805.3	852.9	50.1	45.6	7	0	172
21/04/82	00:07:56	179.0	370.1	26.7	572.6	102.6	14.4	211.0	52	805.1	852.7	50.1	45.7	7	0	176
21/04/82	04:08:00	179.3	370.3	26.7	573.1	101.9	14.4	211.0	51	804.6	852.2	50.0	45.8	7	0	180
21/04/82	08:08:05	178.0	369.9	26.7	572.2	102.7	14.2	211.0	51	803.4	851.0	50.0	45.5	7	0	184
21/04/82	12:08:10	178.0	369.4	26.7	572.2	102.3	14.5	211.0	53	805.4	853.0	49.9	46.1	7	0	188
21/04/82	16:08:17	176.8	369.3	26.7	572.3	102.6	14.4	210.8	53	806.8	854.4	50.1	45.9	7	0	192
21/04/82	20:08:24	177.8	369.8	26.7	572.6	103.4	14.4	210.9	52	804.8	852.4	50.2	45.4	7	0	196
22/04/82	00:08:29	177.5	369.7	26.6	571.1	103.5	14.4	211.0	52	803.7	851.2	50.2	45.5	7	0	200
22/04/82	04:08:34	178.5	370.1	26.5	570.9	102.4	14.3	210.9	50	803.4	850.9	50.3	45.8	7	0	204
22/04/82	08:08:39	178.6	370.0	26.6	571.6	102.6	14.4	211.0	51	802.9	850.4	50.2	45.8	7	0	208
22/04/82	12:08:45	177.6	369.4	26.5	570.8	102.8	14.4	211.0	53	805.8	853.3	50.2	46.0	7	0	212
22/04/82	16:08:51	178.1	369.7	26.8	573.6	103.0	14.5	211.0	52	806.3	853.9	50.2	45.6	7	0	216
22/04/82	20:08:57	178.4	370.1	26.5	571.1	103.3	14.3	211.0	52	807.3	855.0	50.2	45.6	7	0	220

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Table C-8. Endurance Test Record, Part 9 of 10

Date	Time	Pi psia	Ti oF	Qi %	H btu/lb	Mi klb/h	P2 psia	T2 oF	Tr %	KWe	KWm	Freq Hz	Eff %	[illegible]	Trk	File
23/04/82	00:09:02	178.1	369.9	26.6	572.1	102.1	14.4	211.0	51	803.4	851.0	50.3	46.0	7	0	224
23/04/82	04:09:09	178.9	370.2	26.6	571.6	102.4	14.4	210.8	50	803.0	850.6	50.3	45.6	7	0	228
23/04/82	14:14:03	179.6	370.7	26.7	573.2	102.1	14.3	210.8	49	803.9	851.4	50.3	45.6	7	0	232
23/04/82	18:14:10	177.7	369.7	26.8	572.9	102.0	14.3	210.7	52	805.4	853.0	50.3	45.9	7	0	236
23/04/82	22:14:14	178.8	370.2	26.7	572.5	102.2	14.3	210.7	50	803.5	851.1	50.2	45.7	7	0	240
24/04/82	02:14:19	178.2	370.2	26.9	573.8	102.4	14.2	210.7	50	805.8	853.4	50.1	45.4	7	0	244
24/04/82	06:14:26	179.1	370.6	26.8	573.4	100.7	14.3	210.7	49	801.9	849.4	50.3	46.2	7	0	248
24/04/82	10:14:33	177.7	369.7	26.7	572.3	101.5	14.3	210.7	51	802.2	849.8	50.2	46.1	7	0	252
24/04/82	14:14:39	177.1	369.5	26.7	572.3	102.5	14.3	210.6	51	804.3	851.9	50.2	45.7	7	0	256
24/04/82	18:14:47	178.3	369.9	26.9	574.3	101.5	14.2	210.7	51	804.9	852.5	50.2	45.8	7	0	260
24/04/82	22:14:52	178.8	370.4	26.7	573.0	101.8	14.3	210.7	49	803.2	850.8	50.3	45.7	7	0	264
25/04/82	02:14:59	178.9	370.3	26.5	571.2	102.0	14.3	210.7	49	803.1	850.6	50.2	46.0	7	0	268
25/04/82	06:15:06	179.0	370.2	26.8	573.5	101.0	14.4	210.7	50	802.8	850.3	50.3	46.1	7	0	272
25/04/82	10:15:11	177.5	369.7	26.9	573.6	101.7	14.3	210.8	52	804.9	852.5	50.0	45.9	7	0	276
25/04/82	14:15:16	177.9	369.6	27.0	574.6	102.2	14.4	210.7	51	805.1	852.7	50.2	45.6	7	0	28
25/04/82	18:15:23	178.5	369.9	26.9	574.5	101.9	14.3	210.7	51	805.2	852.8	50.2	45.7	7	0	284
25/04/82	22:15:28	178.7	370.3	26.9	574.2	101.3	14.3	210.8	50	804.0	851.6	50.2	45.9	7	1	4
26/04/82	02:15:32	178.6	370.4	26.8	573.2	101.5	14.3	210.8	49	803.0	850.5	50.2	45.6	7	1	8
26/04/82	06:15:39	180.9	371.0	26.6	572.5	101.2	14.3	210.8	48	802.9	850.5	50.3	45.9	7	1	12
26/04/82	10:15:45	178.1	369.8	27.2	577.0	100.6	14.4	210.9	50	804.6	852.2	50.1	45.9	7	1	16
26/04/82	14:15:50	177.5	369.6	26.9	573.9	102.4	14.3	210.8	51	805.1	852.7	50.2	45.6	7	1	20
26/04/82	18:15:55	176.6	369.4	26.9	573.7	101.6	14 3	210.7	53	804.9	852.4	50.0	46.0	7	1	24
26/04/82	22:16:01	178.9	369.9	26.8	574.0	101.5	14.3	210.6	50	804.7	852.2	50.3	45.9	7	1	28
27/04/82	02:16:07	179.5	370.1	26.9	574.8	101.8	14.3	210.3	50	805.2	852.8	50.3	45.5	7	1	32
27/04/82	06:16:12	181.4	371.1	26.7	573.6	101.4	14.2	210.0	48	805.1	852.7	50.4	45.6	7	1	36
27/04/82	10:16:16	178.6	369.9	26.6	572.1	102.4	14.1	210.0	49	804.5	852.0	50.2	45.4	7	1	40
27/04/82	14:16:21	178.3	369.7	26 9	574.2	101.9	14.1	209.9	50	804.7	852.3	50.2	45.4	7	1	44
27/04/82	18:16:28	177.7	369.9	27.0	574.6	101.5	14.2	210.3	50	804.6	852.1	50.2	45.7	7	1	48
27/04/82	22:16:33	178.5	369.7	26.7	572.7	102.1	14.2	210.2	50	803.3	850.9	50.1	45.6	7	1	52
28/04/82	02:16:37	180.2	371.0	26.7	573.0	101.7	14.3	210.5	48	803.2	850.8	50.2	45.7	7	1	56
28/04/82	06:16:43	181.0	371.2	26.7	573.4	101.3	14.3	210.8	48	802.3	849.8	50.1	45.7	7	1	60
28/04/82	10:16:50	179.8	370.4	26.6	572.6	101.6	14.4	210.9	49	801.0	848.5	50.2	45.9	7	1	64
28/04/82	14:16:56	175.4	368.8	27.2	575.7	100.7	14.4	210.9	54	803.4	851.0	50.0	46.2	7	1	68
28/04/82	18:17:02	180.8	371.3	26.5	572.2	101.8	14.5	211.1	48	802.7	850.3	50.1	45.9	7	1	72
28/04/82	22:17:08	180.4	371.2	26.9	574.9	100.8	14.6	211.3	48	802.3	849.8	50.2	46.2	7	1	76
29/04/82	02:17:16	177.6	370.0	27.0	574.8	100.7	14.5	211.3	50	801.6	849.1	50.1	46.2	7	1	80
29/04/82	06:17:22	182.2	371.7	26.7	574.2	101.5	14.6	211.4	47	800.8	848.4	50.1	45.7	7	1	84
29/04/82	10:17:28	177.5	369.6	26.8	573.4	102.0	14.5	211.5	52	805.0	852.6	50.0	46.1	7	1	88
29/04/82	14:17:33	179.2	370.3	26.9	574.2	101.6	14.4	211.2	50	803.4	850.9	50.2	45.8	7	1	92
29/04/82	18:17:39	177.5	369.8	27.0	574.5	101.9	14.4	211.2	52	804.1	851.6	50.1	45.8	7	1	96
29/04/82	22:17:45	179.3	370.6	26.8	574.0	100.9	14.5	211.2	49	801.0	849.3	50.0	46.2	7	1	100
30/04/82	02:17:50	179.8	371.1	26.8	574.4	100.0	14.5	211.2	48	801.7	849.3	50.2	46.5	7	1	104

Table C-8. Endurance Test Record, Part 10 of 10

Date	Time	P1 psig	T1 oF	Q1 %	H btu/lb	M1 klb/h	P2 psia	T2 oF	Tr %	KWe	KWH	Freq Hz	Eff %	DC	trk	file
30/04/82	06:17:56	177.9	370.2	26.9	574.0	100.8	14.4	211.2	50	801.5	849.1	50.1	46.2	7	1	108
30/04/82	10:18:03	179.0	370.0	26.8	573.5	101.6	14.6	211.3	50	802.7	850.2	50.2	46.1	7	1	112
30/04/82	14:18:09	178.6	370.0	26.8	573.6	101.7	14.4	211.1	50	803.4	851.0	50.2	45.9	7	1	116
30/04/82	18:18:14	178.2	370.0	27.1	575.6	101.1	14.5	211.1	51	804.2	851.7	50.1	46.0	7	1	120
30/04/82	22:18:19	180.3	370.5	26.7	573.7	101.8	14.4	211.1	48	804.1	851.6	50.4	45.8	7	1	124
01/05/82	02:18:25	179.5	370.3	27.0	575.3	100.6	14.5	211.1	49	803.3	850.8	50.2	46.2	7	1	128
01/05/82	06:18:30	176.9	369.5	27.1	575.7	101.1	14.3	211.2	53	807.7	855.3	50.0	46.1	7	1	132
01/05/82	10:18:36	178.6	370.0	27.0	574.9	101.0	14.4	211.2	50	803.6	851.2	50.2	46.1	7	1	136
01/05/82	14:18:44	178.0	369.8	27.0	575.1	101.0	14.4	211.1	50	804.3	851.9	50.2	46.1	7	1	140
01/05/82	18:18:50	177.8	369.6	27.0	575.2	101.2	14.4	211.1	51	804.8	852.4	50.1	46.0	7	1	144
01/05/82	22:18:56	178.6	370.2	27.0	574.9	100.9	14.5	211.2	49	802.9	850.5	50.1	46.2	7	1	148
02/05/82	02:19:03	179.7	370.5	26.7	573.1	101.5	14.5	211.2	48	800.9	848.4	50.1	45.9	7	1	152
02/05/82	06:19:09	179.7	370.5	27.0	575.6	100.3	14.4	211.1	49	804.0	851.6	50.2	46.2	7	1	156
02/05/83	10:19:13	178.3	369.8	27.3	576.1	100.2	14.4	211.0	49	802.1	[illegible]	50.2	45.9	7	1	160
02/05/82	14:19:18	178.3	370.1	27.2	576.9	100.3	14.4	210.8	49	804.3	851.9	50.1	46.1	7	1	164
02/05/82	18:19:23	178.8	370.3	27.2	576.6	100.4	14.4	210.8	49	803.7	851.2	50.2	46.1	7	1	168
02/05/82	22:19:31	177.9	369.9	27.0	575.4	100.9	14.3	210.8	49	802.5	850.0	50.1	45.9	7	1	172
03/05/82	02:19:35	178.6	370.1	[illegible]	574.5	100.7	14.3	210.9	50	804.9	852.5	50.0	46.2	7	1	176
03/05/82	06:19:39	180.4	370.8	27.3	576.5	99.6	14.5	210.8	47	801.4	848.9	50.2	45.9	7	1	180

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16. Abstract A 1-MW wellhead generator was tested in 1980, 1981, and 1982 by Mexico, Italy, and New Zealand at Cerro Prieto, Cesano, and Broadlands, respectively. These tests were performed with the participation of the U.S. Department of Energy, the Hydrothermal Power Co., Ltd., and the Jet Propulsion Laboratory, under the auspices of the International Energy Agency. The total flow helical screw expander protable power plant Model 76-1, had been built for the U.S. Government and field-tested in Utah, USA, in 1978 and 1979. The expander had oversized internal clearances designed for self-cleaning operation on fluids that deposit adherent scale normally detrimental to the utilization of liquid-dominated fields. Some testing was done on-grid. Typical expander isentropic efficiency was 40% to 50% with the clearances not closed, and 5 percentage points or more higher with the clearances partly closed. The expander efficiency increased approximately logarithmically with shaft power for most operations, while inlet quality, speed, and pressure ratio across the machine had only small effects. These findings are all in agreement with the Utah test results. Condensing tests produced lower machine efficiencies but also lower flowrates per kW of electricity produced. Based on operating results and cost/benefit analyses in comparison with 1-MW turbine generators, Mexico and Italy rated the screw expander power plant as suitable for noncondensing service in some liquid-dominated fields, although the unit tested needs shaft seal repair before it is returned to service. Improvements of the shaft seal flush water system and the speed control system are important, and closing of the rotor clearances, either through manufacturing changes or operating changes, is necessary for best performance. Lower prices through mass production would broaden the application.

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