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**Organic Rankine-Cycle Power Systems
Working Fluids Study: Topical Report
No. 3 — 2-Methylpyridine/ Water**

R. L. Cole, J. C. Demirgian, and J. W. Allen

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TOPICAL REPORT NO. 3 -- 2-METHYLPYRIDINE/WATER

by

R.L. Cole, J.C. Demirgian,* and J.W. Allen

Energy and Environmental Systems Division
Systems Engineering and Technology Group

September 1987

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CONTENTS

ACKNOWLEDGMENTS	ix
ABSTRACT	1
1 INTRODUCTION	1
2 EXPERIMENTAL APPARATUS	5
2.1 Working Fluid Loop	6
2.1.1 Evaporator/Superheater Section	6
2.1.2 Pressure-Reduction Station	6
2.1.3 Regenerative Heat Exchanger	9
2.1.4 Condenser	12
2.1.5 Diaphragm Metering Pump and Pulsation Damper	13
2.1.6 Liquid- and Vapor-Sampling Stations	13
2.1.7 2-Methylpyridine/Water Degasification Procedure	15
2.2 Fluid Heating Section	15
2.3 Heat Rejection System	15
2.4 Instrumentation, Controls, and Data-Acquisition Systems	16
3 ANALYTICAL TECHNIQUES AND PROCEDURES	17
3.1 Mass-Spectrometric Gas Analysis	17
3.2 Gas Chromatography of High-Boiling Components	18
3.3 Gas Chromatography of Low-Boiling Components	18
3.3.1 Analytical Standard	19
3.3.2 Accuracy and Reproducibility of Data	19
4 SUMMARY OF DYNAMIC LOOP OPERATIONS	24
4.1 Test Run No. 1	24
4.2 Test Run No. 2	24
4.3 Test Run No. 3	28
5 RESULTS	32
5.1 Identification of Liquid-Phase Impurities and Degradation Products	32
5.1.1 Impurities	32
5.1.2 Degradation Products	33
5.2 Liquid-Phase Analysis of High-Boiling Components	34
5.2.1 575°F, High-Boiling Fraction	34
5.2.2 625°F, High-Boiling Fraction	42
5.2.3 675°F, High-Boiling Fraction	46
5.3 Liquid-Phase Analysis of Low-Boiling Components	50
5.3.1 575°F, Low-Boiling Fraction	50
5.3.2 625°F, Low-Boiling Fraction	52
5.3.3 675°F, Low-Boiling Fraction	56
5.4 Vapor-Phase Analysis	61
5.4.1 Hydrogen	62
5.4.2 Methane	62

CONTENTS (Cont'd)

5.4.3	Other Gaseous Degradation Products	64
5.4.4	Background Gases	68
5.5	Determination of Degradation Rates	72
6	CONCLUSIONS AND RECOMMENDATIONS	76
	REFERENCES	77
APPENDIX A:	Daily Averages, Minima, and Maxima of Evaporator Temperature, Evaporator Pressure, and Condenser Pressure	79
APPENDIX B:	Degradation Report for High Boilers	85
APPENDIX C:	Gas Chromatograms for High Boilers	175
APPENDIX D:	Identifications of Selected Impurities and Degradation Products	199
APPENDIX E:	Degradation Reports for Low Boilers	209
APPENDIX F:	Gas Chromatograms for Low Boilers	257

FIGURES

2.1	Schematic Diagram of Organic Rankine-Cycle Test Loop	6
2.2	Overall View of Test Facility	7
2.3	Evaporator Section during Assembly	8
2.4	Section Containing Pump, Condenser, Regenerative Heat Exchanger, and Pressure-Reduction Valves	9
2.5	Data-Acquisition and Control Center	10
2.6	Ideal Test Cycle on a Pressure-Enthalpy Diagram	12
2.7	Schematic Diagrams of Sampling Stations	14
3.1	Replots of First Standard Run and Last Standard Run of Project	22
3.2	Chromatographic Separation of Two Isomers on First and Last Standard Runs	22
5.1	Residue Components vs. Time at 575°F	41
5.2	High-Boiling Degradation vs. Time at 575°F	41
5.3	Concentrations of Selected High-Boiling Components vs. Time at 575°F	43

FIGURES (Cont'd)

5.4	High-Boiling Residue Components vs. Time at 625°F	44
5.5	High-Boiling Degradation vs. Time at 625°F	44
5.6	High-Boiling Degradation vs. Time at 675°F	49
5.7	Degradation of All Low-Boiling Impurities vs. Time at 575°F	51
5.8	Degradation of All Low-Boiling Impurities at 575°F with 18-h Sample Subtracted	51
5.9	Low-Boiling Degradation of Two Components vs. Time at 575°F	52
5.10	Low-Boiling Degradation of Two Acids vs. Time at 575°F	53
5.11	Low-Boiling Degradation of Alkyl Pyridines at 575°F	53
5.12	Low-Boiling Degradation vs. Time at 625°F	55
5.13	Low-Boiling Degradation vs. Time at 625°F with 21-h Sample Subtracted	55
5.14	Low-Boiling Degradation of Two Components vs. Time at 625°F	55
5.15	Low-Boiling Degradation of Two Acids vs. Time at 625°F	56
5.16	Low-Boiling Degradation of Two Components vs. Time at 625°F	57
5.17	Low-Boiling Degradation of Two Additional Components vs. Time at 625°F	57
5.18	Low-Boiling Degradation and Impurities vs. Time at 625°F	58
5.19	Low-Boiling Degradation of Two Impurities vs. Time at 675°F	60
5.20	Low-Boiling Degradation vs. Time at 675°F with the Two Impurities Subtracted	60
5.21	Low-Boiling Degradation of Two Components vs. Time at 675°F	60
5.22	Low-Boiling Degradation of Two Components vs. Time at 675°F	61
5.23	Low-Boiling Degradation Products vs. Time and Temperature	61
5.24	Hydrogen Concentration vs. Time, at Different Temperatures	63
5.25	Methane Concentration vs. Time, at Different Temperatures	64
5.26	Concentrations of Short-Chain Hydrocarbons vs. Time at 575°F	65
5.27	Concentrations of Short-Chain Hydrocarbons vs. Time at 625°F	66

FIGURES (Cont'd)

5.28	Concentrations of Short-Chain Hydrocarbons vs. Time at 675°F	66
5.29	Concentrations of Two Hydrocarbons vs. Time at 575°F	66
5.30	Concentrations of Two Hydrocarbons vs. Time at 625°F	67
5.31	Concentrations of Two Hydrocarbons vs. Time at 675°F	67
5.32	Concentrations of C2 to C5 Alkanes vs. Time and Temperature	68
5.33	Concentrations of C2 to C5 Alkenes vs. Time and Temperature	68
5.34	Concentrations of Two Components vs. Time at 575°F	71
5.35	Concentrations of Two Components vs. Time at 625°F	71
5.36	Concentrations of Two Components vs. Time at 675°F	71
5.37	Total Degradation vs. Time at 575°F	74
5.38	Total Degradation vs. Time at 625°F	75
5.39	Total Degradation vs. Time at 675°F	75

TABLES

1.1	Capsule Tests of Pyridine and Methylpyridines	3
1.2	Results of 1973 Gas-Chromatographic Analysis	4
2.1	Design Conditions for 2-Methylpyridine Loop	11
3.1	Conditions Used for Gas Chromatographic Analysis of High-Boiling Components	19
3.2	Conditions Used for Gas-Chromatographic Analysis of Low-Boiling Components	19
3.3	Analytical Standard for 2-Methylpyridine Degradation Studies	20
3.4	Comparison of Response Factors of the Standard	21
3.5	Retention Times of Standards in Subsequent Runs	23
4.1	Summary of Test Conditions	25
4.2	Summary of Events for Test No. 1	26

TABLES (Cont'd)

4.3	Summary of Temperatures and Pressures in Intervals between Samples for Test No. 1	27
4.4	Summary of Events for Test No. 2	28
4.5	Summary of Temperatures and Pressures in Intervals between Samples for Test No. 2	29
4.6	Summary of Events for Test No. 3	30
4.7	Summary of Temperatures and Pressures in Intervals between Samples for Test No. 3	31
5.1	Identification of Major High-Boiling Degradation Products	35
5.2	Degradation Report with Identification of Major Degradation Products	36
5.3	Summary of Concentrations of Degradation Products at 575°F	41
5.4	Summary of Concentrations of Major Polyalkyl-Substituted Pyridines at 575°F	42
5.5	Summary of Concentrations of Major Dimers of 2-Methylpyridine at 575°F	42
5.6	Summary of Concentrations of Degradation Products at 625°F	44
5.7	Summary of Concentrations of Major Polyalkyl-Substituted Pyridines at 625°F	45
5.8	Summary of Concentrations of Major Dimers of 2-Methylpyridine at 625°F	45
5.9	Concentrations of Selected Dimers, Components, and Percent Degradation at 625°F	46
5.10	Summary of Concentrations of Degradation Products at 675°F	47
5.11	Summary of Concentrations of Major Polyalkyl-Substituted Pyridines at 675°F	48
5.12	Summary of Concentrations of Major Dimers of 2-Methylpyridine at 675°F	48
5.13	Concentrations of Selected Dimers, Components, and Percent Degradation at 675°F	49
5.14	Concentrations of 2-Methylpyridine Degradation Products at 575°F	51
5.15	Concentrations of 2-Methylpyridine Degradation Products at 625°F	54

TABLES (Cont'd)

5.16	Concentrations of 2-Methylpyridine Degradation Products at 675°F	59
5.17	Vapor-Phase Concentrations of Hydrogen and Alkanes	63
5.18	Vapor-Phase Concentrations of C2-Amines and Low-Molecular-Weight Hydrocarbons	65
5.19	Vapor-Phase Concentrations of Various Degradation Products of 2-Methylpyridine	69
5.20	Vapor-Phase Concentrations of Background Gases for 2-Methylpyridine	70
5.21	Total Degradation for High- and Low-Boiling Components at 575°F	72
5.22	Total Degradation for High- and Low-Boiling Components at 625°F	72
5.23	Total Degradation for High- and Low-Boiling Components at 675°F	73
5.24	Summary of Degradation Rates	75

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ABSTRACT

A mixture of 35 mole percent (mol %) 2-methylpyridine and 65 mol % water was tested at 575, 625, and 675°F in a dynamic loop. Samples of the degraded fluid were chemically analyzed to determine the identities of major degradation products and the quantity of degradation. Computed degradation rates were found to be higher than those for Fluorinol 85 or toluene. For this reason (and other reasons, related to fluid handling), other fluids are recommended as the first choice for service in organic Rankine-cycle systems in preference to 2-methylpyridine/water.

1 INTRODUCTION

Recovery of waste heat in an economically acceptable manner from various industrial processes has been a vital facet of U.S. energy policy over the past several years. The Rankine-cycle power system (RCPS), using organic working fluids, has long been recognized as one of the viable technologies. (These systems operate on the Rankine cycle, in which a working fluid is alternately vaporized and condensed using waste heat and a low-temperature heat sink. The high-temperature, high-pressure fluid is expanded through an expansion engine to produce mechanical power or electricity.) Typically, an organic Rankine-cycle power system (ORCPS) can use single-stage turbines and still achieve higher cycle efficiencies than systems using low-temperature steam, because of the relatively low enthalpy drop and full admission through the nozzle made possible by the high molecular weight of the organic fluid.

However, serious concerns about the long-term thermal stability of organic fluids and its effects on system performance, reliability, and overall economic viability have impeded widespread development and deployment of this technology to date. Prototypical systems designed on the basis of thermal-stability results from static capsule testing have failed to operate entirely to the satisfaction of their developers. The working fluid must also be compatible with common materials of construction at system design temperatures. Reliable data are required to establish the maximum temperature and the fluid replacement rate. Dynamic loop testing of working fluids of interest could provide such data for system designers. The findings presented here are part of a concerted effort under way to alleviate performance, reliability, and economic

concerns and to accelerate development and deployment of this technology in the industrial sector of the U.S. economy.

The thermal stability of an organic fluid is a general term used to describe the ability of the fluid to withstand a given temperature without significant decomposition. Above a certain temperature, an organic fluid will begin to decompose at a measurable rate, and this rate will increase with increasing temperature. Even in an "inert" environment, a fluid can decompose as a result of breakage of chemical bonds, without reacting with other materials. Stability against this type of decomposition is a measure of the inherent bond strength of the molecule and has been referred to as *thermal stability*.¹ The term *thermochemical stability* is used to describe the stability of a fluid in contact with the materials in the working environment. Thus, the thermochemical-stability temperature of the fluid provides a limitation on the maximum allowable operating temperature of a prototypical ORCPS. The thermochemical-stability temperature is typically less than the thermal-stability temperature by approximately 100-400°F.¹ In this report, the single term *thermal stability* is used to indicate the stability of a fluid in its working environment.

In a previous study, based on systems analysis entailing performance and economic considerations (rate of return on investment, ROI), water and six organic fluids were identified as capable of harnessing the energy content of a range of industrial waste-heat streams.² Of these fluids, 2-methylpyridine/water, toluene, and water were found to have the best projected ROIs for waste-heat streams exceeding 700°F, and 2-methylpyridine/water and methanol were found to have the best projected ROIs for waste-heat streams under 700°F. However, questions about the long-term thermal-stability temperatures of these fluids for this application could not be explicitly answered on the basis of available information. In some cases, reliable data were either nonexistent or inconclusive. This uncertainty became the motivation for undertaking the current dynamic-loop testing program.

The three fluids investigated in this program are as follows: Fluorinol 85 (a mixture of 85 mole percent [mol %] trifluoroethanol, $\text{CF}_3\text{CH}_2\text{OH}$, and 15 mol % water); 2-methylpyridine/water (a mixture of 35 mol % 2-methylpyridine, $\text{C}_6\text{H}_7\text{N}$, and 65 mol % water); and toluene (methylbenzene, $\text{C}_6\text{H}_5\text{-CH}_3$). Detailed thermodynamic properties and other characteristics of these fluids are listed in Ref. 2. In this report, discussion is limited to 2-methylpyridine/water; Refs. 3 and 4 are similar topical reports on Fluorinol 85 and toluene, respectively.

Two approaches are used to obtain reliable data on thermal stability: static capsule tests and dynamic loop tests. Capsule tests of fluids serve as an important screening tool in qualitatively and, to some extent, quantitatively establishing the effects of pertinent variables on fluid-degradation rates. However, the results cannot be easily or reliably extrapolated to a prototypical system, because not all system operating conditions can be duplicated in the capsule tests. In comparison with a complete system test, dynamic testing in a small loop is a simpler, more cost-effective approach that still simulates system operating conditions well. This approach also allows testing over a wide range of operating temperatures and pressures, including those that could lead to some detrimental effects on an ORCPS due to fluid degradation. (It would be unwise to put an expensive, full-sized system at risk by using it to conduct thermal-stability experiments.)

Reference 1 reports on both static capsule testing and dynamic loop testing of 2-methylpyridine/water. In the static capsule tests, pyridine and various methylpyridines were heated to 720°F in an SAE 1008 carbon steel capsule. Survival times, as defined in Ref. 1, are shown in Table 1.1. After additional screening, two fluids were identified for the present application. The first, labeled RC-1, consists of 60 mol % pentafluorobenzene and the balance hexafluorobenzene. The second, labeled RC-2, consists of 65 mol % water and the balance 2-methylpyridine; this fluid (RC-2) is the subject of this report. The reasons for selecting RC-2 are as follows:

1. RC-2 has an I-factor of 1.38. (Reference 1 provides a definition of the I-factor. Fluids with an I-factor of unity or slightly greater than unity indicate a negative-sloped saturated-vapor line $(\partial T/\partial s)_g$. Such a fluid can be used in systems with a small regenerative heat exchanger, or none at all, without a loss of cycle efficiency. Fluids with I-factors of less than unity, such as RC-1, require a large regenerative heat exchanger to maintain a high cycle efficiency. A slightly higher cycle efficiency was computed for RC-2 than for RC-1, using best estimates of component efficiencies.)
2. RC-2 is nonflammable.

Additional testing with metal coupons in a capsule test showed that RC-2 is incompatible with SAE 4130 steel at 720°F: the reaction produces hydrogen and Fe_3O_4 .¹ Nevertheless, a dynamic loop was constructed using SAE 4130 steel for the evaporator coil. Two tests of 2-methylpyridine/water at 720°F were reported. The first test ended, after 400 h, because of loop failure. Frequent purging was required because of hydrogen formation, and Fe_3O_4 interfered with operation of the automatic valve that controlled evaporator pressure. The second test ran for 1011 h; 2-methylpyridine/water was considered to have failed the test because of the amount of hydrogen gas evolved. The fluid removed after the test was dark amber in color but was free of suspended solids. Analysis by gas chromatograph (GC) showed that three impurities were present in the new fluid, and one additional peak of high-molecular-weight material was found in the used fluid. These results are shown in Table 1.2. The GC column consisted of 4 m of 0.25-in.-O.D. (outside diameter) tubing packed with SE-52 on high-performance Chromosorb W. Helium carrier gas and a thermal-conductivity detector were used.

Reference 5 lists the maximum-use temperature for pyridine (not 2-methylpyridine) as 670°F and recommends testing it and several other fluids for 1000 h

TABLE 1.1 Capsule Tests of Pyridine and Methylpyridines^a

Compound	Survival Time (h)
Pyridine	>336
2-Methylpyridine	>288
3-Methylpyridine	288
4-Methylpyridine	240
2,6-Dimethylpyridine	>288

^aSource: Ref. 1.

TABLE 1.2 Results of 1973 Gas-Chromatographic Analysis^a

Species Elution Time (min at 100°C)	Identification	Concentration (ppm)	
		New Fluid	Used Fluid
3.1 ± 0.15	Impurity	1800	1800
4.8 ± 0.2	Impurity	1700	960
5.1 ± 0.25	Impurity	Unknown	Unknown
8.4 ± 0.3	Degradation	0	370

^aSource: Ref. 1.

or more at operating temperature. Reference 6 reports survival times of pyridine, the three methylpyridines, and their aqueous solutions at 720°F in an SAE 1008 carbon steel capsule. All survived for more than 200 h, but the thermal stabilities of the aqueous solutions were deemed marginal at 720°F.

Reference 7 reports capsule tests of the azeotropic solution of pyridine (again, not 2-methylpyridine) with water. The azeotrope consists of 60% by weight (wt %) pyridine and the balance water. After 168 h at 752°F in the presence of an SAE 1010 carbon steel coupon, only 0.5% degradation of the pyridine (0.3% of the total fluid) was measured, while in the presence of a 6061 aluminum coupon only 1.7% of the pyridine remained. Clearly, material compatibility is an issue with the pyridines.

On the basis of results reported in Refs. 1 and 5-7, we decided to construct our dynamic loop of materials that would minimize their interaction with 2-methylpyridine/water and to conduct the tests over a range of 575-675°F. The upper temperature is close to the maximum temperature attainable with our loop design. Our tests differed from those reported in Ref. 1 in three important ways:

1. We used type 316 stainless steel for our heater tube to minimize the interaction of the fluid with common engineering materials used in the loop.
2. Our tests covered a range of temperatures.
3. Due to major advances in GC technology in the past 14 years, we were able to resolve more than 150 peaks in the samples and to identify most of the major ones.

2 EXPERIMENTAL APPARATUS

Dynamic test loops have previously been designed and constructed to study the thermal stability of organic working fluids for RCPS applications. Heat-addition methods have included direct electrical heating and indirect electrical heating by means of a salt bath or condensing heat-transfer fluid. Most of the loops built by others have used water-cooled condensers but have not included economizers. The types of pumps used have included diaphragm pumps, regenerative turbine pumps, and piston pumps. Fluid flow rates have varied from 10 to more than 250 lb_m/h. The fluid inventory circulation time has varied from 1.8 to 7.8 min for these systems. For comparison, the prototypical organic Rankine-cycle (ORC) engine systems that have been built and operated have a circulation-time range of 2.1–12.6 min.

In our experiment, the basic loop consists of a vaporizer/superheater, a pressure reduction station, an economizer/preheater (regenerative heat exchanger), a condenser, and a diaphragm-type metering pump. Indirect heating using condensing Dowtherm®* A was selected for our system because of its low vapor pressure at relatively high temperature (14.7 psia at 495°F). Figure 2.1 shows a flow schematic of the dynamic test loop used in this investigation. Figure 2.2 shows an overall view of the test facility. Figure 2.3 shows the uninsulated evaporator/superheater section, and Fig. 2.4 shows the section containing pressure-reduction valves, economizer, condenser, metering pump, pulsation damper, and liquid and noncondensable-vapor sampling stations. Figure 2.5 shows the system controls and data-acquisition center.

The dynamic test loops are designed to conduct long-term (approximately 1000 h per test) thermal-stability tests under simulated prototypical thermodynamic operating conditions. Stainless steel (SS, types 304 and 316) is used to minimize potential degradation resulting from interaction with loop materials. The system is designed to be leak-tight to prevent potential contamination of the fluids by in-leakage of air. Sampling stations are provided to periodically withdraw liquid and noncondensable-vapor samples for chemical analysis. Adequate instrumentation and controls are provided for monitoring the loops during steady-state operation, as well as to diagnose off-design operation. Safety controls are provided for automatic shutdown of the system in case of major system malfunctions.

The design conditions for the dynamic loop are listed in Table 2.1. The ideal design-point test cycle is presented on the pressure-enthalpy (P-h) diagram of Fig. 2.6.

The system layout has four major subsystems: the working fluid loop (Sec. 2.1); the fluid heating section (Sec. 2.2); the heat rejection system (Sec. 2.3); and the instrumentation, controls, and data-acquisition systems (Sec. 2.4).

*"Dowtherm®" is a trademark of Dow Chemical USA, Midland, Mich.

FIGURE 2.1 Schematic Diagram of Organic Rankine-Cycle Test Loop

2.1 WORKING FLUID LOOP

The working-fluid loop consists of an evaporator/superheater section, a pair of pressure-reduction valves, a regenerative heat exchanger, a condenser, a metering pump, and a pulsation damper (not shown in Fig. 2.1). A special procedure is used to remove dissolved air from the 2-methylpyridine before filling the loop.

2.1.1 Evaporator/Superheater Section

The evaporator/superheater section is constructed of 0.375-in.-O.D., 0.035-in.-wall type 304 SS tubing. A tube approximately 75 ft long is formed in a coil of eight loops, each approximately 9.4 ft long, to provide a total internal heat-transfer surface area of 6.0 ft². With an average power of 10 kW required to heat the 2-methylpyridine/water, this results in an average heat flux of 5680 Btu/h·ft². The evaporator/superheater section is instrumented with type-E thermocouples at the inlet and outlet.

2.1.2 Pressure-Reduction Station

The pressure-reduction station simulates an expansion turbine, but it produces no power. Two Nupro SS-6BW-STE bellows-sealed stainless-steel valves serve to reduce the pressure of superheated vapor emerging from the evaporator/superheater to the condenser pressure. (Although the exit temperature of the valve is higher than that of the turbine, it is well below the temperature at which significant degradation occurs.

FIGURE 2.2 Overall View of Test Facility

FIGURE 2.3 Evaporator Section during Assembly

FIGURE 2.4 Section Containing Pump, Condenser, Regenerative Heat Exchanger, and Pressure-Reduction Valves

Thus, the error introduced by using a valve instead of a turbine is insignificant.) One of these valves is automatically controlled and requires no manual adjustments during operation.

2.1.3 Regenerative Heat Exchanger

The purpose of the regenerative heat exchanger is to recover a substantial amount of heat from high-temperature, low-pressure vapor that has passed through the pressure-reduction station, rather than rejecting this heat through the condenser.

FIGURE 2.5 Data-Acquisition and Control Center

TABLE 2.1 Design Conditions for 2-Methylpyridine Loop

Component and Location	Temp., T (°F)	Pressure, P (psia)	Fluid Flow Rate (lb _m /h) ^a
Evaporator/superheater			
Dowtherm® A vapor	625	<150	
Working fluid, outlet	600	500	120
Pressure-reduction station outlet	560	18	120
Regenerative heat exchanger			
Vapor, outlet	300	18	120
Liquid, outlet	250	516	120
Condenser			
Vapor	230	18	120
Liquid	208	18	120
Water, inlet ^a	80	<5	[0.6]
Water, outlet ^a	192	<5	[0.6]
Pump			
Inlet	120	18	120
Outlet	120	525	120

^aWith the exception of water flow rates, in square brackets, which are given in gal/min.

Although the prototypical system does not require a regenerative heat exchanger, it reduced electricity consumption in the dynamic loop. The regenerative heat exchanger was used only for the 575°F test. At higher temperatures, the regenerative heat exchanger was bypassed because it caused pressures in the loop to be unstable.

The regenerative heat exchanger consists of 5-in.-O.D., 20-in.-long, schedule 40, type 304 SS pipe. The shell is fitted with a double coil made of a 42-ft-long, 0.5-in.-O.D., 0.035-in.-wall, type 304 SS tube. A tubular spacer baffle centers the coil in an annulus and provides cross-flow conditions across the tube bundle as the vapor moves downward toward the outlet. The coil inlet and outlet pass through the bottom end of the shell via vertical welded nozzles. The high-pressure, low-temperature liquid from the pump is heated by the low-pressure superheated vapor before it flows to the evaporator/superheater section.

FIGURE 2.6 Ideal Test Cycle on a Pressure-Enthalpy Diagram

2.1.4 Condenser

The condenser is a shell-and-tube heat exchanger similar in construction to the regenerative heat exchanger; the organic fluid condenses on the shell side, and laboratory cooling water flows through the tube section. The vapor from the regenerative heat exchanger enters at the bottom of the condenser and flows upward in the shell, where it is condensed by contact with the cold tube. Noncondensable gaseous components tend to accumulate in the condenser, from which they are periodically removed for chemical analysis. The construction material is type 304 stainless steel. The shell is a 25-in.-long, 5-in.-O.D., schedule 40 pipe with spherical caps welded at both ends. The coil -- fabricated from a 50-ft-long, 0.5-in.-O.D., 0.035-in.-wall tube -- is centered in the annulus by a baffle, which directs the vapor in a cross-flow pattern to the lower drain.

2.1.5 Diaphragm Metering Pump and Pulsation Damper

A Milton Roy FR 151-144 diaphragm metering pump with a rating of 27.9 gal/h at 600 psia is used for pressurizing and circulating the fluids. The pump requires approximately 9-psia net positive suction head (NPSH). It is constructed of stainless steel and uses a Teflon®* diaphragm. Teflon® is inert at the design fluid-temperature levels of the pump. The pump flow rate is easily adjusted over a range of 0.1-0.4 gal/min by changing the stroke length (using a micrometer adjustment screw).

A pulsation damper is included in the loop, between the metering pump and the regenerative heat exchanger, to smooth out the pressure fluctuations from the main metering pump. A Pulsatrol 38 damper constructed of stainless steel, it uses a Nordel®† diaphragm. Nordel® has been found to be compatible with 2-methylpyridine in the temperature range of interest for this study. The damper has been modified to pressurize the diaphragm with 2-methylpyridine/water vapor. Inert gases used to pressurize the damper in previous experiments were found to permeate through the diaphragm and cause unacceptable increases in condenser pressure.

2.1.6 Liquid- and Vapor-Sampling Stations

Fig. 2.7 shows schematic diagrams of the sampling stations for liquids (2.7a) and for noncondensable vapors (2.7b). Periodic withdrawal of both liquid and noncondensable-vapor samples is required to monitor the fluid degradation during a test run. Precautions are taken to prevent contamination of the organic fluids during the sample withdrawal process. The liquid sampling station is located between the condenser and the pump. The liquid sampling procedure is simple and requires a 0.25-in.-O.D., 3-in.-long glass sample tube and a vacuum pump. After the tube is attached to the sample port and evacuated, the vacuum valve is closed and the sample valve opened to fill the sample tube. The sample valve is then closed, and the sample tube is removed from the sample port. Two such samples are taken from the loop at each sampling time; the first sample is discarded to remove any stagnant fluid that might be present in the lines leading to the sampling valve.

The noncondensable samples are drawn through the top of the condenser into a sample cooler. A 150-mL SS sampling cylinder is used to draw noncondensable samples from the sample cooler. To obtain a gas sample, a sampling cylinder is attached to the sample cooler and evacuated. After the sample cooler has been filled with vapor and noncondensable gas from the condenser, the sample cooler is valved off and cooled for one hour to condense whatever vapor is present. The valve between the sample cooler and the sample cylinder is then opened briefly to obtain the sample for analysis.

*"Teflon®" is a trademark of E.I. duPont de Nemours & Co., Wilmington, Del.

†"Nordel®" is a trademark of E.I. duPont de Nemours & Co., Wilmington, Del.

a. Liquid Sampling Station

b. Noncondensable-Vapor Sampling Station

FIGURE 2.7 Schematic Diagrams of Sampling Stations

2.1.7 2-Methylpyridine/Water Degasification Procedure

Before the 2-methylpyridine/water is loaded into the loop, dissolved air must be removed; otherwise, dissolved oxygen would react with the 2-methylpyridine during loop operation and give an unrealistic measurement of the degradation rate. The 2-methylpyridine/water is loaded into a vessel, where it is frozen with liquid nitrogen; the gas remaining in the vessel is removed with a vacuum pump. After the valve to the vacuum pump is closed, the 2-methylpyridine/water is allowed to melt and release the dissolved gases into the vessel. Three freeze-evacuate-thaw cycles are performed. The pressure in the vessel is monitored at the end of each thaw to ensure satisfactory removal of the dissolved air.

2.2 FLUID HEATING SECTION

Heat is added to the fluids in a pressure vessel enclosing the evaporator/superheater tube bundle. In this vessel, Dowtherm® A is heated and vaporized using three Watlow electrical immersion heaters. Heat is transferred to the working fluid by condensing the Dowtherm® vapor on the outside surfaces of the evaporator/superheater coil. The test loop uses three 480-V (alternating current), 7.5-kW heaters of the 2-in. by 11-1/2 National Pipe Thread (NPT) screw-plug type; each heater has three elements, for a total of nine heating elements. The heaters have a power density rating of 23 W/in.² with the steel sheath at 343°C (650°F). One heater is wired to provide 7.5 kW of heat, and one element of another heater is wired to provide 2.5 kW. The remaining heater elements are connected to a Barber-Coleman 527Z temperature controller operating at 240 V (alternating current) to provide an additional 0-3.2 kW of heat.

The pressure vessel is constructed of 16-in.-diameter, 50-in.-long, type 304 SS pipe. It is designed to withstand 800°F at 150 psia. One end is closed by a welded cap, and the other end is closed by a flange through which the evaporator/superheater coils pass. The pressure vessel is fitted with a 150-psi rupture disk, a low-liquid-level alarm, a fluid drain, a fluid fill connection, and thermocouples. The system is designed to provide 700°F 2-methylpyridine/water vapor at the maximum allowable temperature for Dowtherm® A (720°F).

2.3 HEAT REJECTION SYSTEM

The heat-rejection system consists of a plastic coolant-storage tank, a heat-exchange coil, and a variable-speed gear pump. The cooling water is drawn from the storage tank by the pump, circulates through the condenser (where it removes heat from the loop), and returns to the storage tank. Chilled water circulating through the heat-exchange coil removes heat from the storage tank, maintaining its temperature at approximately 70°F. A Honeywell electronic process controller on the control panel automatically adjusts the gear-pump speed to maintain the desired condenser pressure.

2.4 INSTRUMENTATION, CONTROLS, AND DATA-ACQUISITION SYSTEMS

Temperatures at various locations in the loop are measured by using type-E Chromel/Constantan thermocouples, and pressures are measured using Sensotech T- and Z-series strain-gauge pressure transducers. Mechanical gauges are installed to measure pressures at other locations and to verify the pressure-transducer readings. The signals from the thermocouples and pressure transducers are recorded by a Digistrip II data logger and are monitored by the safety circuit, which automatically turns the loop off if a malfunction is detected.

Rough control of the heat input to the loop is achieved by manually switching the 480-V, 2.5-kW heater element. Fine control is achieved by a Barber-Coleman 527Z proportional controller acting on the remaining five heater elements. The controller and its heater elements operate on 240-V, single-phase power to provide an additional 0-3.2 kW of heat. This arrangement provides two overlapping ranges of heat: 7.5-10.7 kW and 10.0-13.2 kW. The temperature controller senses the 2-methylpyridine/water vapor temperature immediately upstream of the pressure-reduction valve with a type-K thermocouple.

The condenser pressure is automatically controlled by a Honeywell model R7355C1140 process controller, which adjusts the speed of the coolant pump. The evaporator pressure is automatically controlled by a motor acting on one of the expansion valves. The 2-methylpyridine/water flow rate is controlled by manually adjusting the metering pump stroke.

A Digistrip II, 48-channel data logger is used to collect and record all temperature, pressure, and flow-rate data at half-hour intervals. In addition to its data-logging functions, the Digistrip II sends its measurements for each 20-s period to an Apple II+ computer by means of an RS-232C line. The computer is programmed to (1) accept data from one or two Digistrip data loggers, each transmitting data for each 20-s period; (2) display all of the measurements on the screen; (3) transmit data at half-hour intervals to a digital tape recorder; (4) store up to eight sets of data (taken at half-hour intervals) in buffers; and (5) transmit the contents of those buffers to a dial-up modem, so that the loop can be monitored from a remote location.

Two two-channel strip-chart recorders (Lenseis 6502) continuously monitor the evaporator outlet temperature, evaporator outlet pressure, condenser pressure, and coolant pump speed.

3 ANALYTICAL TECHNIQUES AND PROCEDURES

In the present investigation, both liquid and gaseous (noncondensable-vapor) samples are periodically collected and analyzed. Components of the gaseous samples are identified and quantified by mass-spectrometric analysis. The approach used for the chemical analysis of liquid samples is to first identify the degradation products and then determine the concentration of each degradation product in each 2-methylpyridine/water sample; the sum of degradation-product concentrations is considered to be the total degradation for each sample. Qualitative identification is based upon gas chromatography/mass spectroscopy (GC/MS). Quantitative analysis of the concentration of degradation products is based upon gas chromatographic analysis using a flame ionization detector (FID). Since no single gas-chromatographic column had both the stability and the ability to resolve the entire mixture adequately, the high-boiling-point components were analyzed separately from the low-boiling-point components, using different columns and GC conditions. The data generated by the gas chromatograph were analyzed using custom-written software developed at Argonne for this project. The equipment used and the type of data obtained are described below.

3.1 MASS-SPECTROMETRIC GAS ANALYSIS

The gaseous samples are collected from the condenser in 150-mL SS cylinders and analyzed with a modified Consolidated Engineering Co. CEC21-620/gas mass spectrometer. The sample cylinder is connected to the spectrometer, and the air between the two is pumped out. After a satisfactory vacuum is attained, the sample container is opened to the mass spectrometer. The sample is allowed to expand to 100 torr pressure in the inlet and a 3-mL calibrated volume; the 3 mL is further expanded in a 3000-mL reservoir and introduced into the spectrometer.

Gas molecules are ionized by bombardment with 70-eV electrons, and the ions are injected into a permanent magnetic field, where they are sorted according to mass number:

$$M/e = KH^2/V \quad (3.1)$$

where M is the mass of the ion, e is the charge of an electron, K is a calibration constant, H is the magnitude of the magnetic field, and V is the applied voltage. The focused ions impinge on a collector, where they give up their charge, and the signal thus generated is amplified and delivered to a strip-chart recorder. Every molecular species has a unique spectrum of fragments, isotopic ions, and multiply charged ions that identifies it. A tabulation of ion peak heights at each mass number relative to the largest (base) peak is obtained from a spectrum of the pure gas. Since the height of the base peak is proportional to the pressure of the gas in the spectrometer, the spectrum is made at known pressure to determine the sensitivity coefficient (i.e., peak height/pressure).

In analyzing a gas mixture, the first step after reloading a spectrum and measuring the peak heights is to sort out the components by their patterns. The second

step is to ascertain the true height of the base peak of each component x and to calculate its partial pressure pp_x :

$$pp_x = h_x / s_x \quad (3.2)$$

where h_x is the peak height of component x and s_x is the instrument sensitivity for that component. The percentage of each component x is obtained by summing the partial pressures of all the components and normalizing:

$$f_x = \frac{pp_x}{\sum_i pp_i} \times 100 \quad (3.3)$$

where pp_i is the partial pressure of component i and f_x is the quantity of component x , expressed as a percentage of the total.

The accuracy of analysis depends on various factors, including the accuracy of pressure measurements for the standard, the stability of the electronic components, and the nature of the sample. If two or more components -- such as N_2 , CO , and C_2H_4 -- have the same base peaks, the sorting out by pattern becomes more difficult and less reliable. For relatively simple mixtures, an overall accuracy of about $\pm 2\%$ can be achieved. For complex mixtures, a more realistic accuracy is $\pm 5\%$.

3.2 GAS CHROMATOGRAPHY OF HIGH-BOILING COMPONENTS

High-boiling components were analyzed separately from the low-boiling components, because no single combination of GC column and analytical conditions could resolve all of the degradation components. A Hewlett Packard (HP) 5880A GC with a relatively nonpolar 30 m x 0.32 mm bore x 0.25 μ m film DB5 column was used to analyze the high boiling components. Analytical conditions used are shown in Table 3.1. Injections were splitless. Data were interpreted for components that eluted after naphthalene (15 min).

As many as 172 components eluted in a 30-min period and were resolved in the high-boiling region. The main degradation products found were dimers and alkyl-substituted pyridines. Retention indexes reproduced reliably. For example, the 408-retention index component eluted with an actual index of 407.8 ± 0.3 . Some column degradation (characterized by retention-time variation, peak broadening, and loss of resolution) was encountered toward the end of the analysis. All peak integrations and data handling were performed on a Perkin-Elmer (PE) 7500 data station using Chromatographics 3 software. All data were checked and corrected to ensure the accuracy of the peak integrations.

3.3 GAS CHROMATOGRAPHY OF LOW-BOILING COMPONENTS

The HP 5880A GC used to analyze the high-boiling components was also used to analyze the low-boiling components. A different column, 30 m x 0.25 mm bore x 0.25 μ m film DX4, was used. Analytical conditions, shown in Table 3.2, also differed from those

TABLE 3.1 Conditions Used for Gas Chromatographic Analysis of High-Boiling Components

Item	Specified Value
Temperature (°C)	
Initial	40
Final	220
Time (min)	
Initial	2
Final	0
Ramp rate (°C/min)	4

TABLE 3.2 Conditions Used for Gas-Chromatographic Analysis of Low-Boiling Components

Item	Specified Value
Temperature (°C)	
Injector	270
Initial	40
Final	250
Detector	290
Time (min)	
Initial	5
Final	10
Ramp rate (°C/min)	4

used for the high-boilers. All injections were splitless. Data were interpreted for components that elute before naphthalene.

3.3.1 Analytical Standard

The same analytical standard was used for analysis of both the high- and low-boiling components (see Table 3.3). Samples were analyzed in series of six. First, the standard was run, followed by four samples, and then by the final standard. Five such series were run. This methodology required the running of back-to-back standards at the beginning and end of each series to verify the reproducibility and sensitivity of the system.

3.3.2 Accuracy and Reproducibility of Data

The detector sensitivity was highly reproducible. The detector response, in area counts per nanogram injected, is shown in Table 3.4 for the analytical standard. The first column is the GC run number. The column heads are the response factors in area counts per nanogram for pyridine, 3-methylpyridine, 4-methylpyridine, 3-ethylpyridine, 3,4-dimethylpyridine, quinoline, 6-methylquinoline, 4,4'-dimethyldipyridine, and 1,2-dipyridylethane. The alkyl pyridines have a response of approximately 25 counts per nanogram, while the quinolines have a response of 28 counts per nanogram; the standard deviation is 6%. The response slowly increases as samples are run. The two geometrical isomers, 3-methylpyridine and 4-methylpyridine, were not completely resolved. As the column degraded throughout this project, the chromatographic resolution deteriorated and the area integration became less accurate.

The column degradation resulted in a loss of chromatographic resolution. Peak widths were significantly broader by the end of the project. This can be clearly seen in

TABLE 3.3 Analytical Standard for 2-Methylpyridine Degradation Studies

Component	Concentration (ppm)
Benzene	175.8
Pyridine (PYR)	54.4
3-methylpyridine (3-PIC)	106.8
4-methylpyridine (4-PIC)	53.8
3-ethylpyridine (EtPYR)	55.0
3,4-dimethylpyridine (C2PYR)	105.2
Naphthalene	131.4
Quinoline (QUIN)	126.4
6-methylquinoline (MeQUIN)	56.6
4,4'-dimethyl,2,2'-dipyridyl (C2DIP)	101.6
Phenanthrene	184.2
1,2-bis(4-pyridyl)ethane (P2ETHANE)	70.0

Figure 3.1, which contains replots of the first and last standard runs on the project. The loss of resolution for the 3-methylpyridine and 4-methylpyridine isomers is shown in Figure 3.2. The two isomers were well separated in the first run (65); however, by the last run (93), they almost completely overlap. The retention time of the components decreased on subsequent runs, indicating breakdown of the internal surface of the column. Table 3.5 shows the retention times for each of the components in the standard and the standard deviation throughout the series of runs.

The quantitative results of this study depend on detector sensitivity and are reproducible and accurate to within 10%. The loss of chromatographic resolution, as shown by the peak broadening, means that individual components which elute near each other in the early analytical runs coelute in the later analytical runs. Their individual identities and concentrations cannot be determined in the later runs, but the combined concentration and total degradation can be determined.

As a measure of the effect of column degradation, the 675°F, 921-h sample was analyzed twice: it was the first sample analyzed (i.e., analyzed before the 575°F data) and the next to last sample analyzed (i.e., analyzed in sequence with all the other 675°F samples). The total concentrations are in agreement; they vary by slightly greater than 800 ppm out of almost 14,000 ppm (or 6%), well within the limit of experimental error. The difference between the first and last samples lies in the resolution of the components. For example, the 3-methylpyridine can be separated and quantified. The agreement of the data within 6% means that the total degradation figures are reproducible, even though fine detail has been lost because of column degradation. The retention index report for this sample is appended to the retention index report for the 675°F data in Table E.21 of App. E (low-boiling components).

TABLE 3.4 Comparison of Response Factors^a of the Standard^b

Run	PYR	3-PIC	4-PIC	EtPYR	C2PYR	QUIN	MeQUIN	C2DIP	P2ETHANE
65	25.46	21.06	28.16	22.80	24.28	25.33	26.50	21.75	13.23
68a	26.31	21.53	30.24	25.44	24.86	26.54	27.92	24.50	15.91
68	25.51	20.42	25.86	22.93	23.54	25.43	26.70	22.82	14.99
73	24.38	20.10	34.83	25.75	25.30	27.22	28.66	26.90	17.60
75	25.15	18.82	32.30	24.22	23.44	25.04	26.10	22.10	15.97
80	24.19	17.88	39.89	25.02	24.96	27.34	28.80	28.07	18.41
81	23.81	17.49	39.20	25.73	24.90	26.72	28.14	26.97	17.83
86	24.78	17.38	41.80	26.47	25.75	27.64	28.94	27.33	17.96
87b	25.24	17.83	43.35	26.45	25.40	28.04	29.36	28.49	19.74
87c	26.76	19.26	44.50	27.38	27.38	29.81	31.27	30.80	21.99
92	29.21	18.37	46.71	28.91	28.15	30.47	31.27	32.02	23.26
93	26.82	17.83	47.90	26.91	28.01	29.89	31.15	30.19	23.10
Average	25.63	19.00	37.90	25.67	25.50	27.46	28.79	26.83	18.33
Deviation	1.42	1.39	7.14	1.70	1.52	1.75	1.83	3.27	3.05

^aRatio between known concentration and the corresponding area of each chemical under its gas chromatogram curve.

^bFull names of components listed in Table 3.3.

FIGURE 3.1 Replots of First Standard Run (top) and Last Standard Run of Project (y-axes in mV, x-axes in min)

FIGURE 3.2 Chromatographic Separation of Two Isomers (3-methylpyridine, left peaks; 4-methylpyridine, right peaks) on First and Last Standard Runs (vertical axis is detector signal, horizontal axis is time)

TABLE 3.5 Retention Times (min) of Standards in Subsequent Runs^a

Run	PYR	3-PIC	4-PIC	Et-PYR	C2PYR	NAPH	QUIN	C2DIP
65	7.130	11.439	11.701	15.352	18.962	30.120	36.835	54.567
68a	7.116	11.463	11.677	15.317	18.920	30.046	36.731	54.408
68	7.096	11.440	11.655	15.295	18.892	30.015	36.700	54.382
73	7.068	11.400	11.612	15.255	18.854	30.006	36.704	54.389
75	6.927	11.396	11.612	15.252	18.847	29.979	36.666	54.340
80	6.990	11.299	11.500	15.147	18.744	29.885	36.576	54.266
81	6.990	11.297	11.499	15.143	18.735	29.871	36.560	54.241
86	6.950	11.254	11.453	15.099	18.686	29.827	36.511	54.198
87b	6.977	11.282	11.472	15.125	18.705	29.831	36.502	54.177
87c	6.991	11.281	11.477	15.112	18.689	29.800	36.477	54.159
92	6.936	11.221	11.412	15.053	18.636	29.758	36.447	54.138
93	6.947	11.235	11.423	15.061	18.647	29.742	36.425	54.100
Average	7.010	11.334	11.541	15.184	18.776	29.907	36.595	54.280
Deviation	0.070	0.083	0.099	0.0996	0.1078	0.1177	0.1245	0.1326

^aFull names of components listed in Table 3.3.

4 SUMMARY OF DYNAMIC LOOP OPERATIONS

Approximately 2700 h of 2-methylpyridine/water testing in three test runs, ranging from 575 to 675°F, are summarized in this section. During these test runs, vapor temperatures and pressures at the evaporator/superheater exit, condenser pressures and the temperatures of condensates, and temperatures of vapors and liquids at the economizer inlet and exit were recorded every half hour. The maximum and minimum cycle operation temperatures and pressures were analyzed for each of the runs to verify relatively steady-state operation of the dynamic loop. A summary of these data for each of the runs is presented in Table 4.1. Detailed information on temperatures and pressures on a daily basis for each of the tests is given in App. A.

4.1 TEST RUN NO. 1 (532 h at 575°F)

The nominal operating conditions for this run are 575°F and 500 psia at the evaporator/superheater exit, 18 psia condenser pressure, and 120°F subcooled condensate temperature. The actual average operating temperature was 574.7°F, with minimum and maximum values of 535.3 and 612.8°F, respectively. The minimum and maximum values of the pressure at the evaporator/superheater exit were 445.5 and 521.9 psia, respectively, with an overall average value of 494.7 psia. The condenser pressure was between 17.54 and 18.72 psia, with an overall average value of 17.96 psia.

Table 4.2, derived from the operations log of the test, provides further insight into loop operations for this run. The most serious problem was an unplanned automatic shutdown due to unstable evaporator pressure, which led to termination of the test after 532 h. Investigation showed that the regenerative heat exchanger formed a feedback loop that caused the pressure oscillations. Therefore, the regenerative heat exchanger was bypassed before beginning the second test run.

Additional information can be gained from Table 4.3, which summarizes temperatures and pressures in the intervals between samples. The temperatures for all but four entries in Table 4.3 were within 5°F of the nominal temperature. It is expected that the temperatures during startup (the 0-18-h interval) would be low. The loop required approximately 26 h to stabilize its temperature to within 5°F of the nominal 575°F, so the low temperature carried over into the next time interval (18-161 h). At the end of the test, the evaporator temperature increased to 612.8°F in response to the unstable pressure. Because of the feedback loop formed by the regenerative heat exchanger, the evaporator pressure could not be maintained within 10 psi of the nominal pressure as desired. The automatic shutdown occurred when the pressure dropped below 450 psia. The process controller easily maintained the condenser pressure within 3 psi of the nominal 18 psia.

4.2 TEST RUN NO. 2 (1153 h at 625°F)

For this test, the nominal conditions were 625°F evaporator temperature, 500 psia evaporator pressure, and 18 psia condenser pressure. The actual average evaporator

TABLE 4.1 Summary of Test Conditions

Run No.	Elapsed Time (h)	Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
		Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
1	532	574.7	535.3	612.8	494.67	445.50	521.90	17.96	17.54	18.72
2	1153	624.3	617.6	629.9	499.66	469.90	516.30	18.09	16.73	19.38
3	992	675.2	643.9	681.7	499.32	454.30	579.40	17.73	16.24	20.65

TABLE 4.2 Summary of Events for Test No. 1 (575°F)

Elapsed Time (h)	Event
Sample-Taking	
18	First samples
161	Second samples
328	Third samples
497	Fourth samples
532	Fifth samples (test completed)
Other Events	
15	Adjust evaporator temperature.
18	Adjust evaporator temperature.
112	Adjust flow rate.
136	Restart computer.
207	Adjust coupling of motor drive to evaporator control valve.
532	Automatic shutdown due to unstable evaporator pressure. Test completed.

temperature was 624.3°F, with minimum and maximum values of 617.6 and 629.9°F, respectively. The average evaporator pressure was 499.7 psia, with minimum and maximum values of 469.9 and 516.3 psia, respectively. The average condenser pressure was 18.09 psia with minimum and maximum values of 16.73 and 19.38 psia, respectively.

Table 4.4 gives the elapsed time at which the samples were drawn and summarizes events that were recorded in the operations log. No serious operational problems occurred during this test, although slightly unstable temperatures and pressures were noted at 476 and 748 h.

Table 4.5 summarizes the temperatures and pressures in the intervals between gas and liquid samples. Temperatures were within 5°F of the nominal 625°F except at startup and shutdown and, briefly, in the 525-h to 693-h interval. Evaporator pressures were generally maintained within 15 psi of the nominal 500 psia, although the desired 10-psi limit could not be maintained. Exceptions to the 15-psi limit occurred in the 693-h to 836-h interval, when unstable operation was noted, and at shutdown. The condenser pressure was maintained within 3 psi of the nominal 18 psia as desired.

TABLE 4.3 Summary of Temperatures and Pressures in Intervals between Samples for Test No. 1 (575°F)

Interval (h)	Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
0-18	564.7	535.3	572.8	494.74	473.00	515.70	17.93	17.70	18.19
18-161	574.5	568.1	576.7	494.44	475.40	512.50	17.96	17.77	18.28
161-328	574.9	574.0	576.4	495.76	469.60	514.90	17.96	17.67	18.24
328-497	575.0	573.9	576.3	494.84	474.60	521.90	17.97	17.54	18.72
497-532	577.5	574.4	612.8	489.53	445.50	513.50	17.96	17.78	18.11
Overall	574.7	535.3	612.8	494.67	445.50	521.90	17.96	17.54	18.72

TABLE 4.4 Summary of Events for Test No. 2 (625°F)

Elapsed Time (h)	Event
Sample-Taking	
20	First samples
188	Second samples
358	Third samples
525	Fourth samples
693	Fifth samples
836	Sixth samples
1153	Seventh samples (test completed)
Other Events	
20	Adjust flow rate.
22	Adjust evaporator temperature.
44	Adjust evaporator temperature.
51	Computer restarted.
68	Adjust evaporator temperature.
310	MODEM malfunction. Computer restarted without MODEM.
476	Unstable operation (pressure and temperature) noted.
748	Unstable operation noted.

4.3 TEST RUN NO. 3 (992 h at 675°F)

For this test, the nominal conditions were 675°F evaporator temperature, 500 psia evaporator pressure, and 18 psia condenser pressure. These conditions differed from the nominal conditions of Test Nos. 1 and 2 only in the evaporator temperature. For this run, the actual average evaporator temperature was 675.2°F, with minimum and maximum values of 643.9 and 681.7°F, respectively. The average evaporator pressure was 499.32 psia, with minimum and maximum values of 454.3 and 579.4 psia, respectively. The average condenser pressure was 17.73 psia, with minimum and maximum values of 16.24 and 20.65 psia, respectively.

Table 4.6 gives the elapsed times at which the samples were drawn and summarizes events that were recorded in the operations log. As the table shows, the condenser required purging of noncondensable gases on three occasions to prevent excessively high condenser pressure. On these occasions, the coolant pump operated at or near its maximum speed, and unstable loop operation was observed. Automatic shutdowns occurred twice. At 509 h, a brief spike of 563 psia in the evaporator caused the first shutdown (lasting 18 h). At 914 h, a brief spike of 579 psia in the evaporator caused the second shutdown (lasting 49 h). In both cases, the loop was restarted and samples were obtained within 6 h of the restart to determine whether any air had leaked into the loops during the shutdowns. At 796 h, maintenance personnel shut off the 480-V

TABLE 4.5 Summary of Temperatures and Pressures in Intervals between Samples for Test No. 2 (625°F)

Interval (h)	Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
0-20	620.7	617.7	624.5	497.20	488.00	503.60	18.12	17.14	19.07
20-188	625.2	619.7	629.9	500.18	488.70	513.60	18.09	16.77	19.38
188-358	625.2	622.0	627.3	499.64	486.60	512.50	18.08	17.05	19.20
358-525	624.5	621.8	626.7	499.16	486.50	510.80	18.08	16.73	19.29
525-693	624.7	619.8	626.7	499.50	486.50	511.90	18.11	16.91	19.32
693-836	624.8	622.6	626.8	501.45	469.90	510.20	18.11	17.01	19.36
836-1153	622.9	617.6	627.1	499.08	475.90	516.30	18.08	16.89	19.14
Overall	624.3	617.6	629.9	499.66	469.90	516.30	18.09	16.73	19.38

TABLE 4.6 Summary of Events for Test No. 3 (675°F)

Elapsed Time (h)	Event
Sample-Taking	
1	First samples
22	Second samples
191	Third samples
359	Fourth samples
513	Fifth samples
532	Sixth samples
678	Seventh samples
850	Eighth samples
920	Ninth samples
992	Tenth samples (test completed)
Various Events	
21	Adjust flow rate and evaporator temperature.
146	Adjust flow rate and evaporator temperature.
219	Restart computer.
285	Adjust evaporator temperature.
286	Purge noncondensable gases from condenser.
292	Purge noncondensable gases from condenser.
477	Purge noncondensable gases from condenser.
509	Automatic shutdown due to high evaporator pressure. Loop restarted after 18 h.
652	Restart computer.
796	Maintenance personnel shut off power to heaters for 10 min. Loop continues to operate.
914	Automatic shutdown due to high evaporator pressure. Loop restarted after 49 h.

power to the loop heaters for approximately 10 min. The power to the rest of the loop remained on, and the loop continued to operate, although the evaporator temperature dropped to 655°F.

Table 4.7 summarizes the temperatures and pressures in the intervals between gaseous and liquid samples. Temperatures were within 5°F of the nominal 650°F except at startups, immediately before the first automatic shutdown, and during the cutoff of power to the heaters. Although the average evaporator pressure of 499.32 psia is close to the nominal pressure of 500 psia, the evaporator pressures have larger excursions from the nominal value than were observed in either the first or second test. This is to be expected because of the faster degradation rate at the higher temperature of this test. All of the condenser pressures were within 3 psi of the nominal 18 psia.

TABLE 4.7 Summary of Temperatures and Pressures in Intervals between Samples for Test No. 3 (675°F)

Internal (h)	Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
0-22	668.5	643.9	674.5	500.66	485.70	513.10	17.67	16.98	18.33
22-191	674.2	669.4	679.1	498.63	480.20	513.80	17.70	16.34	18.87
191-359	676.9	672.9	681.7	500.08	477.50	516.60	17.94	16.66	20.65
359-509 ^a	674.5	672.8	676.6	500.26	481.50	563.10	17.71	16.63	18.72
509-513	672.3	652.7	676.6	497.49	482.10	508.30	18.25	17.55	18.88
513-532	674.2	673.2	677.2	499.91	485.90	510.70	17.63	16.24	18.46
532-678	674.6	671.7	676.2	500.54	477.80	514.80	17.69	16.87	18.72
678-850	675.8	655.3	678.3	499.16	479.90	512.70	17.68	17.04	18.49
850-914 ^b	676.8	675.8	677.8	501.34	454.30	579.40	17.70	17.19	18.29
914-920	670.7	664.0	673.8	498.69	478.80	512.80	17.61	17.12	17.98
920-992	676.3	673.3	677.8	492.86	481.30	508.80	17.64	17.15	18.22
Overall	675.2	643.9	681.7	499.32	454.30	579.40	17.73	16.24	20.65

^aLoop down for 18 h at the end of this time period.

^bLoop down for 49 h at the end of this time period.

5 RESULTS

Impurities and degradation products were identified and quantified for each sample. Chemical reactions leading to the major degradation products were identified, and degradation rates for each test were computed.

5.1 IDENTIFICATION OF LIQUID-PHASE IMPURITIES AND DEGRADATION PRODUCTS

Impurities and degradation products in the liquid samples were identified by gas chromatograph/mass spectrometer (GC/MS), which produced a unique spectrum of molecular fragments for each component, and by gas chromatography/Fourier transformation infrared (GC/FTIR) spectroscopy. Components were identified by comparing their spectra with catalogued spectra of known compounds. The spectra of components are shown in Apps. B (high boilers) and E (low boilers). The retention time of the compound in the gas chromatograph was then correlated with the identification. Because of column degradation, peak broadening, coelution, and the multiplicity of geometric isomers, only the most important components were identified.

5.1.1 Impurities

One of two regions that elute before 2-methylpyridine (2MP) is noted as the pyridine (PYR) region. It consists of pyridine and other nitrogen-containing, five-and-six-membered rings. Also present are very small amounts of benzene, toluene, and xylenes. These components are impurities present in the 2MP. They are always present in decreasing concentration, because they cannot be formed from oxidation or ring cleavage (which appear to be the primary mechanisms for 2MP degradation).

The pyridine region is the most difficult to quantify. Due to the solvent effect, the peak widths of those components that elute immediately before the solvent greatly increase, and the components merge together and connect to the solvent peak itself. The only solution to this problem, multidimensional GC, was tried but could not be applied because of column instability. The peak integrations were individually checked and the region was reintegrated as required, but resolution was poor. We estimate a 30% integration range for this region. To reduce inaccuracies of individual components, the entire region is treated as one component.

An impurity that degrades rapidly was noted in the 575°F, 18-h sample. An IR spectrum was obtained for the component and is shown in App. D, Fig. D.1. It appears to be an amino, alkyl pyridine. This interpretation is based on the amine absorbances at 3500 cm^{-1} , the alkyl absorbances at 3100-2900 cm^{-1} , and the pyridine ring absorbances at 1600-1400 cm^{-1} .

The 2MP used for the 675°F loop test was less pure than that used at 575°F and 625°F; it consisted of a mix of the distilled and mixed 2MP stock that was also used for the previously described tests at 575°F and 625°F and some undistilled 2MP mixed with

water. The result was a starting material that was only 97.5% pure. (Only the purest 2MP commercially available was purchased.) Two components eluting before the pyridine region consisted of more than 22,000 ppm, and 4-methylpyridine amounted to 2291 ppm.

The 2.5% (25,945 ppm) impurity level in the starting material has several significant effects on the data. First, and most importantly, the degradation rate of the impurities could and did exceed the degradation rate of the 2MP. This means that the composition of the fluid changed rapidly as the more reactive impurities yielded less reactive degradation products. The concentrations of these products leveled off as all of the impurity that formed them was consumed. Some of these degradation products catalyzed or reacted with the 2MP to increase the initial rate. Other degradation products degraded to gases, such as hydrogen, methane, ethane, ethene, propane, and propene, and left the liquid phase, thus reducing the total concentration of impurities in the liquid phase.

5.1.2 Degradation Products

The other region to elute before 2MP consisted of highly volatile material (VOL): ammonia, low-molecular-weight alkanes, and acetone. These components were identified by GC/FTIR. The IR spectra for ammonia, an alkene, and acetone are shown in App. D, Figs. D.2-D-4, respectively. The U.S. Environmental Protection Agency (EPA) vapor-phase reference spectra are plotted above the actual spectra for ammonia and acetone.

The formation of ammonia indicates the nitrogen-carbon bond is reactive. The presence of ammonia as more than one peak indicates it is bound as ammonium salts, such as ammonium formate and ammonium acetate, which decompose thermally in the GC injector (270°C). Because the ammonia was bound by the neutralization with carboxylic acids, it was not observed in the vapor-phase analysis. The low-molecular-weight alkanes and alkenes would also be formed from ring cleavage. They are soluble in 2MP and are in solution, but being nonreactive and volatile, they are also present in the vapor phase. Acetone would be formed as a hydrolysis product of ring cleavage of nitrogen from the ring carbon connected to the methyl group. Other unidentified carbonyl components were also observed in low concentration and were not in the IR library. These are alkenones, formed (as acetone was) from ring cleavage. To eliminate any possibility of cross-contamination, acetone was not used as a cleaning agent in the laboratory for the duration of the analyses.

The major oxidation and hydrolysis products are acetic acid and formic acid. These components were also identified by GC/FTIR. These components were present in the initial material but their concentration increased significantly in the loop samples. Figures D.5 and D.6 show the infrared spectra of acetic acid and formic acid, respectively. Also plotted are the EPA library matches for the two acids. These acids appear to be derived from hydrolysis of acetonitrile, a product of ring cleavage. The acids probably exist in solution as the ammonium salt described previously.

Two degradation products were found at 625°F but not at the lower temperature: N-ethyl acetamide and acetamide. Infrared spectra for these components are shown in

Figs. D.7 and D.8. The EPA vapor-phase library identifications are also shown for verification of the identities. Both would be formed from ring cleavage around the nitrogen and oxidation of the carbon adjacent to the nitrogen to a carbonyl. This reaction appears to compete with the hydrolysis reactions noted above, forming formic acid and acetic acid.

A major class of degradation products in the high-boiling region is alkyl-substituted pyridines. These consist of C2-pyridines and C3-pyridines. The large number of potential geometrical isomers makes the identification of each impossible and results in a large number of isomers, each in low concentration but with the total being large. The most prevalent isomer, a C2-pyridine (P310), eluted after 24 min and had a retention index of 310. These alkylated species were formed from reaction of ring fragments produced by ring cleavage with unreacted 2-methylpyridine. C2-bipyridyls were also found and are evidence of the dimerization reaction.

In addition to the above degradation products, low levels of acetonitrile were formed. The formation of acetonitrile explains the fate of the nitrogen of the 2MP ring and reveals why so little was in the vapor phase. Figure D.9 shows the IR spectrum in the 993-h sample, plotted with the EPA vapor-phase library match.

Very small quantities of alkyl-substituted quinolines, indoles, and indenenes were also identified in the high-boiling region. Many components could not be identified because of the low chromatographic resolution, resulting in background-ion interference. Identifications were made using a VG 12-250 GC/MS using the same column and GC conditions used for quantification.

The major high-boiling degradation products, described by retention index, are listed in Table 5.1. A complete degradation report for the 675°F, 993-h sample, with identifications included, is listed in Table 5.2.

5.2 LIQUID-PHASE ANALYSIS OF HIGH-BOILING COMPONENTS

The higher boiling fraction consisted of dimers of 2-methylpyridine (2MP) and polyalkyl-substituted pyridines. The large number of isomers possible accounts for the great number of degradation products obtained. At lower temperatures, degradation appears to proceed (and most degradation products increase) steadily. Thirteen selected components constituted approximately 40% of the degradation products out of the more than 150 total degradation products of the higher boiling fraction for each sample. Retention index reports for the high-boiling components are presented in App. B, and replotted chromatograms are presented in App. C.

5.2.1 575°F, High-Boiling Fraction

The data are summarized in Table 5.3. Five samples were taken throughout the 532-h run. The first sample was the initial charge of 2MP prior to its being put into the loop, the 0-h sample. A sample was removed the next day (18 h), and samples were then

TABLE 5.1 Identification of Major High-Boiling Degradation Products

Retention Index	Name	Notes ^a
408	C5H9-pyridine	MI = 147, unsaturated sidechain(s)
416	C5H11-pyridine	MI = 149, saturated sidechain(s)
420	C5H11-pyridine	MI = 149, saturated sidechain(s)
435	C5H9-pyridine	MI = 147, unsaturated sidechain(s)
437	C5H9-pyridine	MI = 147, unsaturated sidechain(s)
548	C2-bipyridyl	MI = 184
558	C2-bipyridyl	MI = 184
562	Unknown	
569	C2-diazofluorene	MI = 196, see structures below noise
585,596	Unknown	Large noise, Base=253, unidentified ^b

^aMI = molecular ion.

^b"Base" = base, or largest, ion.

removed at the rate of one per week until 532 h had passed; this was the last sample. For the 575°F, 532-h sample, 108 components were resolved and quantified in the high-boiling region. The total measured impurities (column 2) are composed of three parts: initial impurities present in the undegraded 2MP (column 3), a residue (column 4) that was present in the loop at the beginning of the test, and the high-boiler degradation (column 5). The total measured high boilers (column 2) correspond to the totals listed in the detailed sample reports in App. B.

Although the loop was carefully flushed with acetone, ethanol, and distilled water (in that order), the residue left over from earlier attempts to test 2MP in the loop apparently was not soluble in those solvents. Thus, two components are seen in the 18-h sample that were not present in the initial charge. The residue is not stable and degrades steadily throughout the test. Figure 5.1 is a plot of the concentrations of these components. They are present at almost 240 ppm at 18 h and decrease to only 2.9 ppm at 532 h. These residue components are probably air oxidation products that form in the loop between tests or form from residual air present in the loop. Because the residue components are easily resolved and do not correspond to degradation products, the test is considered valid. The removal of these residue peaks from the total results in a relatively smooth rate of high-boiler degradation throughout the test. Figure 5.2 plots the degradation at 575°F.

Although more than 100 degradation products were found in the high-boiling region, seven major components constituted approximately 40% of the total degradation. Those with retention indexes in the 400s are polyalkyl-substituted pyridines. Those with

TABLE 5.2. Degradation Report with Identification of Major Degradation Products^a

Peak No.	Name	Aromatic Retention Index, ARI	Conc. (ppm)	Ret. Time (min)	Area ^b
1	C4-pyridine	396.4	8.83	15.07	71.6
2	C5H11-pyridine	398.7	1.24	15.23	10.0
3		399.6	1.11	15.30	9.0
4	C5H11-pyridine	401.2	3.30	15.44	26.7
5	C5H11-pyridine	403.6	12.30	15.66	99.7
6		405.6	2.15	15.85	17.4
7	C5H9-pyridine	407.9	45.14	16.07	365.7
8	C5H9-pyridine	409.7	10.36	16.24	83.9
9		410.7	1.42	16.33	11.5
10		412.3	10.66	16.48	86.4
11		413.2	4.96	16.56	40.1
12		414.4	2.37	16.68	19.2
13		415.1	3.40	16.75	27.5
14	C5H11-pyridine	415.9	40.14	16.82	325.2
15	C5H11-pyridine	419.6	82.14	17.17	665.4
16		421.9	0.62	17.39	5.0
17		422.6	0.85	17.45	6.9
18	C5H9-pyridine	424.8	6.20	17.65	50.2
19		427.1	1.32	17.88	10.7
20		430.0	30.84	18.14	249.8
21		431.9	3.96	18.32	32.1
22		433.1	4.20	18.44	34.0
23	C5H9-pyridine	434.9	19.28	18.61	156.1
24	C5H9-pyridine	437.4	21.36	18.84	173.0
25		438.7	9.88	18.96	80.0
26	C6H13-pyridine	439.9	17.49	19.08	141.7
27		441.2	2.42	19.20	19.6
28		442.4	13.19	19.32	106.8
29	C6H13-pyridine	447.1	14.52	19.75	117.6
30		449.2	3.83	19.95	31.0
31		450.1	8.88	20.04	71.9
32		453.2	4.30	20.33	34.8
33		453.9	9.03	20.39	73.1
34	C1-quinoline	456.5	20.19	20.64	163.5
35		459.9	10.34	20.96	83.8

TABLE 5.2 (Cont'd)

Peak No.	Name	Aromatic Retention Index, ARI	Conc. (ppm)	Ret. Time (min)	Area ^b
36		461.4	0.67	21.11	5.4
37		462.5	4.80	21.21	38.9
38		465.2	2.19	21.46	17.7
39		467.7	0.80	21.70	6.5
40		469.4	14.64	21.85	118.6
41	C6H13-pyridine	471.7	7.51	22.07	60.8
42	C1-quinoline	473.6	2.41	22.25	19.5
43	C1-quinoline	474.6	2.02	22.34	16.4
44	C1-quinoline	475.3	2.35	22.41	19.0
45		478.0	2.02	22.67	16.3
46		479.6	2.13	22.82	17.3
47		480.5	1.08	22.90	8.7
48		482.3	3.27	23.07	26.5
49		483.3	2.28	23.16	18.5
50	C1-quinoline	484.6	9.56	23.29	77.4
51	C1-quinoline	485.7	5.13	23.39	41.5
52	C1-quinoline	487.4	7.81	23.55	63.2
53	C6H13-pyridine	488.8	8.11	23.68	65.7
54		490.9	2.07	23.88	16.8
55		492.6	4.81	24.04	39.0
56		494.3	2.27	24.20	18.4
57		495.3	5.97	24.30	48.3
58		496.3	3.42	24.39	27.7
59		497.7	1.46	24.52	11.8
60		498.4	2.13	24.58	17.2
61		500.1	3.24	24.75	26.2
62		500.9	2.22	24.82	17.9
63		504.7	1.62	25.18	13.2
64		506.1	1.30	25.31	10.5
65		506.8	3.23	25.38	26.2
66	C7H13-pyridine	511.7	7.82	25.83	63.4
67	C2-quinoline	512.5	8.97	25.92	72.7
68		514.8	0.86	26.13	6.9
69		516.4	2.38	26.28	19.3
70		517.8	0.82	26.42	6.7

TABLE 5.2 (Cont'd)

Peak No.	Name	Aromatic Retention Index, ARI	Conc. (ppm)	Ret. Time (min)	Area ^b
71		518.6	1.50	26.49	12.1
72		519.3	4.22	26.55	34.2
73		520.5	1.62	26.66	13.1
74	C4-indene	522.1	9.96	26.82	80.7
75	C3-quinoline	524.3	3.45	27.02	27.9
76		525.8	1.41	27.17	11.4
77		529.4	5.72	27.50	46.3
78		533.0	1.42	27.84	11.5
79	C4H9-quinoline	535.7	7.83	28.09	63.4
80		537.3	0.80	28.25	6.5
81		538.5	4.87	28.36	39.4
82	C2-bipyridyl	541.2	21.53	28.61	174.4
83	C3-quinoline	542.6	3.15	28.75	25.5
84		543.7	1.89	28.85	15.3
85	C3-bipyridyl	544.8	5.88	28.95	47.6
86	C2-bipyridyl	548.2	56.05	29.27	274.0
87	C2-bipyridyl	550.5	20.53	29.49	100.3
88		553.3	1.82	29.75	8.9
89		557.0	1.60	30.10	7.8
90	C2-bipyridyl	558.4	27.40	30.24	133.9
91		561.4	10.29	30.52	50.3
92		563.6	2.08	30.72	10.1
93		564.9	13.56	30.84	66.2
94		566.7	3.23	31.02	15.8
95	C2-bipyridyl	567.7	14.65	31.11	71.6
96		569.3	21.56	31.26	105.4
97		572.5	3.83	31.56	18.7
98		574.1	22.99	31.71	112.4
99		575.0	6.76	31.80	33.0
100		576.3	2.35	31.92	11.5
101		577.6	1.26	32.04	6.1
102		579.4	1.14	32.21	5.5
103		581.8	3.34	32.43	16.3
104		583.7	1.40	32.61	6.8
105		585.2	11.38	32.75	55.6

TABLE 5.2 (Cont'd)

Peak No.	Name	Aromatic Retention Index, ARI	Conc. (ppm)	Ret. Time (min)	Area ^b
106		586.0	6.89	32.83	33.7
107		587.3	2.55	32.95	12.5
108		587.9	1.38	33.01	6.7
109		589.0	3.36	33.11	16.4
110		589.9	3.05	33.20	14.9
111		592.5	10.40	33.44	50.8
112		594.6	5.73	33.64	46.4
113		595.6	9.79	33.74	79.3
114		602.1	1.85	34.35	15.0
115		606.7	0.62	34.78	5.0
116		609.5	0.80	35.04	6.5
117		611.5	2.35	35.24	19.0
118		612.4	5.12	35.32	41.5
119		614.4	1.18	35.50	9.6
120		615.9	2.81	35.64	22.7
121		619.4	1.80	35.97	14.6
122		619.6	1.32	36.00	10.7
123		621.1	0.90	36.13	7.3
124		622.9	1.00	36.31	8.1
125		625.4	1.44	36.54	11.6
126		629.0	0.80	36.88	6.5
127		631.0	0.83	37.07	6.7
128		632.6	2.65	37.21	21.5
129		638.1	2.78	37.74	22.5
130		640.1	0.82	37.92	6.6
131		641.4	0.82	38.05	6.6
132		645.5	7.09	38.43	57.4
133		646.9	1.90	38.56	15.3
134		649.3	1.56	38.79	12.6
135		652.4	0.98	39.08	7.9
136		653.7	0.89	39.20	7.2
137		655.2	0.64	39.35	5.2
138		657.7	1.99	39.58	16.1
139		661.7	0.98	39.96	7.9
140		662.5	1.30	40.04	10.5

TABLE 5.2 (Cont'd)

Peak No.	Name	Aromatic Retention Index, ARI	Conc. (ppm)	Ret. Time (min)	Area ^b
141		664.7	0.72	40.24	5.8
142		669.4	2.49	40.68	20.2
143		674.5	0.84	41.16	6.8
144		679.1	0.72	41.59	5.9
145		686.4	0.85	42.28	6.9
146		691.0	3.54	42.71	28.7
147		697.0	3.35	43.28	27.1
148		697.5	1.91	43.33	15.4
149		698.5	6.05	43.42	49.0
150		700.8	1.51	43.63	12.2
151		704.5	1.21	43.98	9.8

^aSample file: 42675h993.001a
 COMMENTS: HP 675F 993Hr lul no spk splss
 Total concentration: 982.371 ppm
 Total number of peaks interpreted: 151

^bArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE 5.3 Summary of Concentrations (ppm) of Degradation Products at 575 °F

Time (h)	Total High Boilers	Background Init. Charge	Residue	High-Boiler Degradation
0	1.5	1.5	0	0
18	281.8	1.5	239.2	41.1
161	240.6	1.5	67.4	171.7
329	337.0	1.5	22.4	313.1
532	347.7	1.5	2.9	343.3

FIGURE 5.1 Residue Components vs. Time at 575°F

FIGURE 5.2 High-Boiling Degradation vs. Time at 575°F

retention indexes in the 500s are C2-bipyridyl. The seven selected components are listed in Tables 5.4 and 5.5. These components are identified by their retention indexes and by gas chromatography/Fourier transform infrared spectroscopy, and these identifications are then correlated with the retention indexes.

It can be seen from these tables that the concentrations of these components increase. The sum of the concentration of these seven selected components are plotted versus time in Fig. 5.3. The steady increase is evident.

The fifth column of Table 5.5 shows the retention-index totals for the selected dimers (retention index above 500). The sixth column is the percent of the selected dimers in the total degradation. These selected dimers account for a steadily increasing percentage of the total degradation. The last two columns show the totals for all seven selected components and their percents of the total. The dimers and major polyalkyl-substituted pyridines make up about 40% of the total degradation.

5.2.2 625°F, High-Boiling Fraction

A total of seven samples were removed from the loop and analyzed. Quantitative data were based upon the average of the standard run prior to and after each sample. The degradation in the high-boiling region at 625°F was much higher than that observed in the 575°F samples. Degradation increased steadily with time.

TABLE 5.4 Summary of Concentrations (ppm) of Major Polyalkyl-Substituted Pyridines at 575°F (RI = retention index)

Time (h)	RI 408	RI 416	RI 420	RI 435
0	0	0	0	0
18	0	0.7	2.2	0.8
161	6.2	10.7	24.3	10.6
329	10.1	21.3	33.9	22.1
532	17.2	27.1	32.1	26.7

TABLE 5.5 Summary of Concentrations (ppm) of Major Dimers of 2-Methylpyridine at 575°F (RI = retention index)

Time (h)	RI 562	RI 574	RI 585	Selected Dimers	% of Dimer	Selected Component	% of Component
0	0	0	0	0	-	0	-
18	1.0	0	0	1.0	2.43	4.70	11.4
161	4.4	2.8	6.6	13.8	8.04	65.61	38.2
329	5.4	9.3	17.5	32.2	10.30	119.60	38.2
532	12.5	15.7	14.8	43.0	12.50	146.10	42.6

FIGURE 5.3 Concentrations of Selected High-Boiling Components vs. Time at 575°F

Table 5.6 indicates the total degradation for the 625°F data. The degradation column lists the total concentrations of all components that eluted in the high-boiling region. Initial impurities in the starting material totaled only 1.5 ppm. These components are reported in the background column of Table 5.6. The residue column corresponds to two components not present in the initial fluid but occurring in high concentration in the 22-h sample. Both the background and residue values are subtracted from the degradation column to obtain the total high-boiling degradation, reported in the last column.

Because the fluid used for the 625°F test was prepared from the same batch as the fluid used for the 575°F test, a second zero-hour sample was unnecessary. The 21-h sample again showed a large residue peak, which decreased by 75% after 189 h and almost disappeared by 359 h. The decreasing residue is shown in Fig. 5.4. The 2- to 4-ppm concentration of a component at the appropriate retention index from 525-1153 h may be another degradation product formed. The chromatograms show degradation products throughout the high-boiling range.

The total degradation products formed in the high-boiling region amounted to almost 1500 ppm. The total degradation data and the degradation data for the selected components are plotted as a function of time in Fig. 5.5. The high-boiling degradation is only a fraction of the total degradation. The degradation in the much more concentrated lower-boiling-point region must be added to that of the high-boiling region to obtain total degradation.

The selected components are of two types. The lower plot consists of dimers of 2-methylpyridine. These all have retention indexes greater than 500. The middle plot of Fig. 5.5 consists of alkyl-substituted pyridines formed from the breakdown of a pyridine ring into fragments and their subsequent reaction with another pyridine ring added to the dimers of the lower plot. The total of the 13 selected components constitute 35-40% of the high-boiling degradation products. The alkyl-substituted pyridines all have retention indexes between 400 and 500. Tables 5.7 and 5.8 summarize the individual concentration data for the alkyl-substituted components and the dimers, respectively. Table 5.9 contains the total concentrations for the dimers and the sum of the dimers and alkyl-substituted pyridines.

TABLE 5.6 Summary of Concentrations (ppm) of Degradation Products at 625°F

Time (h)	Total High Boilers	Background Init. Charge	Residue	High-Boiling Degradation
21	202.60	1.5	85.35	115.75
189	594.83	1.5	20.53	572.80
359	669.04	1.5	2.78	664.76
525	881.16	1.5	2.72	876.94
694	913.20	1.5	1.62	910.08
837	1316.50	1.5	4.16	1310.83
1153	1459.30	1.5	3.15	1454.62

FIGURE 5.4 High-Boiling Residue Components vs. Time at 625°F

FIGURE 5.5 High-Boiling Degradation vs. Time at 625°F

TABLE 5.7 Summary of Concentrations (ppm) of Major Polyalkyl-Substituted Pyridines at 625°F (RI = retention index)

Time (h)	RI 408	RI 416	RI 420	RI 435	RI 437	RI 450
21	3.10	2.09	9.81	2.72	2.15	2.29
189	11.23	20.73	42.62	19.07	14.53	12.64
359	11.99	27.66	36.09	22.91	15.40	14.57
525	15.37	34.59	38.92	30.15	15.97	14.11
694	20.43	24.95	49.53	36.37	21.14	19.79
837	30.37	26.10	63.45	46.38	27.19	25.53
1153	23.40	32.64	59.05	44.26	23.47	20.25

TABLE 5.8 Summary of Concentrations (ppm) of Major Dimers of 2-Methylpyridine at 625°F (RI = retention index)

Time (h)	RI 548	RI 558	RI 562	RI 569	RI 574	RI 585	RI 596
21	1.53	0	4.40	4.69	0	0	0.75
189	11.73	7.86	11.71	8.66	6.83	10.18	5.10
359	24.19	14.49	19.77	14.52	11.75	13.33	9.88
525	29.71	22.11	22.64	28.32	25.81	23.04	17.12
694	26.94	24.67	27.14	33.66	36.29	25.74	19.52
837	44.26	37.24	25.41	48.71	59.74	38.20	32.11
1153	46.20	58.73	35.72	64.06	92.44	59.95	36.80

Retention indexes were exceptionally reproducible. For example, the retention-index 408 component eluted with an actual index of 407.8 ± 0.3 . This reproducibility made peak comparison straightforward, especially in light of retention-time shifts of several tenths of a minute. The column showed retention-time variations, peak broadening, and a loss of resolution as a result of gradual degradation throughout the analysis.

The number of components chromatographically resolved in the high-boiling region was exceptionally high. By 189 h, 145 components were chromatographically resolved. This increased to 172 components at 1153 h. The large number of components was eluted over a 30-min period. The replotted chromatograms for the 625°F data are

TABLE 5.9 Concentrations of Selected Dimers, Components, and Percent Degradation at 625°F

Time (h)	Selected Dimers (ppm)	% Dimer	Selected Components (ppm)	% Components
21	11.37	9.8	33.53	29.0
189	62.07	10.8	182.89	31.9
359	107.93	16.2	236.55	35.6
525	168.75	19.2	317.86	36.2
694	193.96	21.3	366.17	40.2
837	285.67	21.8	504.69	38.5
1153	393.90	27.1	596.97	41.0

presented in App. C. Each chromatogram is presented twice: the chromatograms were first plotted with the most degraded samples set at full scale to emphasize the relative concentrations of the major components; the chromatograms were then replotted with certain regions attenuated to show the large number of low concentration components present. The sample reports are included in App. B.

5.2.3 675°F, High-Boiling Fraction

A total of ten samples were removed from the loop and analyzed. Quantitative data were based upon standards run prior to and after the samples. The loop had two automatic shutdowns. The first was at 509 h (lasting 18 h) and the second at 914 h (lasting 49 h). There was discontinuity in degradation products at each shutdown.

Table 5.10 shows the high-boiling degradation for the 675°F test. The background is much higher, because the 2-methylpyridine was prepared from a different batch than for the lower-temperature tests. However, the background is easily resolved, so the test remains valid.

The zero-hour sample was first run through the loop and drained. This sample then contained a direct measure of the residue peak present immediately upon startup. The zero-hour residue peaks amounted to almost 46 ppm, reduced to 0 ppm after 22 h. The components that appeared at the same retention index at times in excess of 500 h are probably degradation components.

High-boiling degradation was lower than at 625°F. High-boiling degradation products reached a maximum of 1100 ppm just prior to the automatic shutdown at 914 h. The degradation decreased after the shutdown and then began to increase slowly until the end time, 992 h, was reached. Only degradation in the high-boiling region is included in these data; the low-boiling-region data must also be included to characterize the total degradation.

TABLE 5.10 Summary of Concentrations (ppm) of Degradation Products at 675°F

Time (h)	High-Boiling Degradation	Background Init. Charge	Residue	Total High Boilers
0	0	29.9	45.76	75.66
22	233.79	29.9	0	263.69
191	482.70	29.9	0	512.60
359	684.81	29.9	0.81	715.52
514	695.74	29.9	0	725.64
532	808.39	29.9	2.55	840.84
678	977.40	29.9	2.49	1009.80
850	1057.84	29.9	3.43	1091.20
921	847.20	29.9	1.32	878.42
992	949.17	29.9	3.30	982.37

The reason the high-boiling degradation is less at 625°F than at 675°F is that the higher temperature favors ring cleavage to form alkyl pyridines. The high-boiling region consists of dimers and polyalkyl-substituted pyridines. The trend to ring fragmentation is emphasized in Tables 5.11 and 5.12, which list the concentrations of the selected polyalkyl-substituted pyridines and dimers, respectively. The three lower-boiling components eluting with retention indexes of 408, 416, and 420 are in higher concentration at higher temperature. The concentration of the component with retention index 437 is approximately equal at both temperatures. All other components that elute after the 437 component are in lower concentration at higher temperature. The only exception is the dimer at 548, which increases in concentration by approximately 20% at higher temperature.

Table 5.13 lists the total concentrations of selected dimers and of selected polyalkyl-substituted components (selected components), as well as their percentages of the total degradation. The amount of dimer formed at 675°F is only two thirds of that formed at 625°F (see Table 5.7). This lowers the total for all the selected components. At both 625 and 675°F, the percent of selected components out of the total degradation of the higher-boiling fraction is the same, approximately 40%. The difference is due both to an increase in lower-boiling components at retention indexes of 408-420 and to a decrease in the total degradation.

Figure 5.6 is a plot of high-boiling degradation products at 675°F (selected dimers, selected polyalkyl pyridine components, and total selected dimers and polyalkyl pyridines). The lower line again represents the dimer concentration; the upper, the total concentration. The discontinuities at shutdown times (509 and 914 h) are apparent. By the difference between the two lower lines, the figure makes clear the lower dimer concentration and greater selected polyalkyl-pyridine concentration.

TABLE 5.11 Summary of Concentrations (ppm) of Major Polyalkyl-Substituted Pyridines at 675°F (RI = retention index)

Time (h)	RI 408	RI 416	RI 420	RI 435	RI 437	RI 450
0	0	0	2.11	0	0	0
22	8.40	8.91	41.67	1.93	8.11	2.47
191	25.78	29.35	68.71	12.93	15.72	4.21
359	39.55	40.50	78.46	19.83	19.20	7.70
514	24.04	19.54	32.98	18.81	17.04	8.68
532	43.33	32.18	77.95	23.07	20.35	8.47
678	54.65	45.71	93.09	24.50	24.16	10.57
850	60.30	38.88	97.17	23.27	22.26	9.53
921	48.81	35.47	72.78	19.79	20.06	8.50
992	45.14	40.14	82.14	19.28	21.36	8.88

TABLE 5.12 Summary of Concentrations (ppm) of Major Dimers of 2-Methylpyridine at 675°F (RI = retention index)

Time (h)	RI 548	RI 558	RI 562	RI 569	RI 574	RI 585	RI 596
0	0	0	0	0	0	0	0
22	5.13	1.71	2.36	0	0	3.54	0
191	13.80	4.95	3.74	6.34	2.65	3.88	5.74
359	25.73	14.42	6.22	12.26	5.15	5.58	3.97
514	32.16	18.73	6.79	12.24	17.15	9.30	6.55
532	35.42	17.01	8.12	14.80	14.51	5.83	6.14
678	47.08	25.56	10.77	20.26	16.96	10.50	9.09
850	59.56	28.96	12.58	22.94	29.38	10.35	10.14
921	46.04	22.94	9.29	20.93	21.51	5.29	8.25
992	56.05	27.40	10.29	21.56	22.99	11.38	9.79

TABLE 5.13 Concentrations of Selected Dimers, Components, and Percent Degradation at 675°F

Time (h)	Selected Dimers (ppm)	% Dimer	Selected Components (ppm)	% Components
0	4.00	--	6.11	--
22	12.74	5.45	84.23	36.0
191	41.10	8.51	197.80	41.0
359	73.33	10.70	278.57	40.7
514	130.50	18.80	251.59	36.2
532	101.83	12.60	307.18	38.0
678	140.22	14.30	392.90	40.2
850	173.91	16.40	425.32	40.2
921	134.25	15.80	339.66	40.1
992	159.46	16.80	376.40	39.7

FIGURE 5.6 High-Boiling Degradation vs. Time at 675°F

The number of components chromatographically resolved in the high boiling region is not as great as at 625°F. The maximum number of components chromatographically resolved was only 151, with most of the samples having 135 components. The replotted chromatograms for the 675°F data are presented in App. C. Each chromatogram is presented twice, as was done for the 625°F high-boiling region. (The chromatograms were first plotted with the most degraded samples set at full scale, then replotted with certain regions attenuated; the sample reports are included in App. B.)

5.3 LIQUID-PHASE ANALYSIS OF LOW-BOILING COMPONENTS

The low-boiling fraction consisted of a variety of products, including initial impurities, products resulting from ring cleavage, and products resulting from hydrolysis of other products. Because of the large impurity component, which degrades rapidly in the loop, the samples of unused fluid are not useful as a baseline for degradation comparisons. Instead, the first sample taken 18-22 h after starting a test run is used as the basis for comparison. Retention index reports for the low-boiling components are presented in App. E, and replotted chromatograms are presented in App. F.

5.3.1 575°F, Low-Boiling Fraction

Degradation in the low-boiling region was relatively low at 575°F. The increase in degradation products from the 18-h initial sample to the final sample removed at 532 h was 1474 ppm. Figure 5.7 shows the total concentration of all low-boiling impurities and degradation products. The initial high concentration is due to the high concentration of 4-methylpyridine, approximately 3000 ppm. Table 5.14 lists the total concentrations of low-boiling impurities and degradation products and the concentrations of selected major degradation products. Table 5.14 shows that the initial charge contained higher total degradation than the 18-h sample. This higher value is due primarily to the greater amount of pyridine and pyridine-related components present as impurities. These components were unstable and degraded by the time the 18-h sample was taken.

The 18-h sample is used as a basis for comparison for degradation throughout each run. The initial material was never subjected to the loop, but it does provide a reference. The initial material and the loop samples were both degrading as a function of time; it appears more appropriate to compare those samples that were exposed to the loop in order to even out the effect of degradation of stored samples. Figure 5.8 shows the data with the values of the 18-h sample subtracted from the total degradation and impurities. Degradation appears to be linear. The loop shutdown just prior to the 532-h sample appears to have had only a minimal effect on total degradation.

All components in the volatile region were totaled and treated as a single entity. Figure 5.9 shows these totals. The values are fairly level until the 532-h sample. The increase was due to air incursion, which caused oxidation of the ring after the loop shutdown.

The pyridine region (PYR) results are also plotted in Fig. 5.9. Components initially totaled 500 ppm but decreased to approximately 150 ppm. Their rapid degradation is one reason why the 18-h sample is used as the standard instead of the starting material. These components were always in decreasing concentration because they could not be formed from oxidation or ring cleavage, which appear to be the primary mechanisms for 2MP degradation.

The pyridine region is the most difficult to quantify. Due to the solvent effect, the peak widths of those components that elute immediately before the solvent greatly increase and the components merge together and connect to the solvent peak itself. The

FIGURE 5.7 Degradation of All Low-Boiling Impurities vs. Time at 575°F

TABLE 5.14 Concentrations (ppm) of 2-Methylpyridine Degradation Products at 575°F

Time (h)	Vola- tiles	PYR Region	4-Methyl Pyridine	Acetic Acid	Formic Acid	C2-PYR P310	Other Cx-PYR	Total
0	79	500	2828	134	30	0	707	4438
18	135	180	3084	176	67	45	243	4119
161	91	153	3151	286	68	230	614	4576
328	121	156	3169	351	83	315	764	4856
532	669	137	3283	390	110	341	746	5593

FIGURE 5.8 Degradation of All Low-Boiling Impurities at 575°F with 18-h Sample Subtracted

FIGURE 5.9 Low-Boiling Degradation of Two Components vs. Time at 575°F

peak integrations were individually checked and the region was reintegrated as required, but resolution was poor. We estimate a 30% integration range for this region. To reduce inaccuracies of individual components, the entire region is treated as one component.

Figure 5.10 shows the concentration of acetic acid and formic acid as a function of time. The increase appears to have been linear and was not affected by the air incursion prior to the 532-h sample.

Figure 5.11 shows the concentration of the major C2-pyridine (P310) and all the other alkyl pyridines (Cx-PYR). These Cx-PYR values were obtained by subtracting all the identified impurities and degradation products from the total degradation. It can be seen that the C2-pyridine concentration increases at approximately the same rate as the other substituted components. Air incursion before the 532-h sample was removed from the loop had no effect upon alkylation.

5.3.2 625°F, Low-Boiling Fraction

Degradation was relatively low at 625°F. The increase in total degradation products was just over 1500 ppm after 1153 h. This was similar to the values for the 575°F run. The greatest increase for the 625°F degradation products was for the high boilers, as reported in Sec. 5.2. The first sample removed from the loop, at 20 h, was used as the basis for the data analysis presented. The 20-h sample showed lower total degradation products and impurities than the initial material. The initial material sample reported at 575°F was the same initial material used for the 625°F samples. The higher level in the initial sample is due to components in the pyridine region, which degrade rapidly at 625°F and then level out.

An interesting characteristic of degradation of low boilers at this temperature is the leveling out of degradation products. Many of the degradation products appear to level out at a constant concentration. Major increases are found for the high boilers and for the volatile region. Table 5.15 contains a summary of the major low-boiling degradation products found at 625°F. As noted in Sec. 5.1, two new degradation products, n-ethyl acetamide and acetamide, were detected.

FIGURE 5.10 Low-Boiling Degradation of Two Acids vs. Time at 575°F

FIGURE 5.11 Low-Boiling Degradation of Alkyl Pyridines at 575°F

Figure 5.12 shows the total low-boiling degradation and impurities for the 625°F samples as a function of time. The high initial level is due to a high concentration of 4-methylpyridine. Figure 5.13 replots the data with the values of the 21-h sample removed. Degradation appears to be low and linear. There is a steeper initial rate increase at 188 h, which then levels off. Because the loop ran flawlessly throughout the 1153 h, there were no unexpected air incursions that could have affected degradation.

The volatile and pyridine regions are shown in Fig. 5.14. The products in the pyridine region decreased slightly throughout the time studied. This was also the case for the 575°F data and is due to the highly reactive nature of these components. The volatile region increased significantly throughout the run. These volatile components showed the most significant increase for the low boiling components. The increase was steady; the volatile components approximately tripled during the more than 1100 h studied. For the 575°F, the volatile region increased only at 532 h, when there was an air incursion into the loop.

Acetic acid and formic acid were also formed. However, the increase in concentration was not as great as expected. Figure 5.15 is a plot of these acids as a

TABLE 5.15 Concentrations (ppm) of 2-Methylpyridine Degradation Products at 625°F

Time (h)	Vola- tiles	PYR Region	4-Methyl Pryidine	Acetic Acid	Formic Acid	C2-PYR P310	Other Cx-PYR	N-Et Acet.	Acet- amide	Total
20	196	198	3335	200	76	42	234	15	32	4286
188	280	213	3464	323	99	214	683	17	16	5095
358	322	201	3434	351	88	255	753	24	19	5192
525	450	219	3438	360	88	273	831	29	30	5445
693	441	209	3483	327	65	267	877	36	37	5475
836	487	192	3497	357	80	280	942	39	43	5637
1153	567	196	3582	353	78	244	1016	39	42	5873

FIGURE 5.12 Low-Boiling Degradation vs. Time at 625°F

FIGURE 5.13 Low-Boiling Degradation vs. Time at 625°F with 21-h Sample Subtracted

FIGURE 5.14 Low-Boiling Degradation of Two Components vs. Time at 625°F

FIGURE 5.15 Low-Boiling Degradation of Two Acids vs. Time at 625°F

function of time. The formic acid concentration was approximately level throughout. The acetic acid increased rapidly to the high level obtained for the 575°F, 532-h sample and then leveled off.

Figure 5.16 shows the concentration of n-ethyl acetamide and acetamide as a function of time. Their concentrations were approximately equal and increased slowly throughout the period studied.

Most of the degradation products formed were alkyl-substituted pyridines. The most prevalent one, a C2-pyridine with a retention index of 310, leveled off at a concentration of half that found at 575°F. There was a sudden increase to 214 ppm at 188 h, after which the concentration held steady. The total concentration of substituted pyridines did increase slowly. The concentrations of these components were obtained by subtracting the concentration of the volatiles, pyridine region, 4-methylpyridine, acetic acid, formic acid, acetamide, and N-ethyl acetamide from the total concentration. Because it was not possible to chromatographically resolve the low concentration of 3-methylpyridine from the very high concentration of 4-methylpyridine, the 3-methylpyridine concentration is included in the 4-methylpyridine concentration for the subtraction. Figure 5.17 is a plot of the 310 component and other alkyl-substituted pyridines for the time studied.

The apparent degradation at 625°F was much lower than expected. It appears that the 50°F increase in temperature was insufficient to activate the cleavage of new bonds; however, it was adequate to cause some of the degradation products to themselves degrade and form new products and different quantities of previously formed products. The leveling of the concentrations of many components formed at 575°F was first observed at this temperature.

5.3.3 675°F, Low-Boiling Fraction

The analysis of the 675°F data was the most difficult. The problem with column degradation was most severe for these samples, because they were the last ones analyzed. In addition to the loss of chromatographic resolution, there are more coeluting peaks than for the 625 and 575°F samples. The acetic acid formed at 575 and 625°F was

FIGURE 5.16 Low-Boiling Degradation of Two Components vs. Time at 625°F

FIGURE 5.17 Low-Boiling Degradation of Two Additional Components vs. Time at 625°F

readily identified and separated from other components. For the 675°F analysis, a sufficient number of degradation products elute near the acetic acid to make separate identification and quantification impossible.

In addition to the loss in resolution, two other factors tended to reduce the accuracy of the data. Because the sample begins with 25,000 ppm of impurities and we are expecting degradation of no more than a few thousand parts per million, we must analyze the small increase in a very large number. In effect, we are subtracting two very large numbers to obtain a small number, which is the resulting degradation. The other problem is that we have reached the linear range of the detector, due to the large concentrations of several of the components. This has the effect of causing the degradation to be underreported. Because of these analytical problems, it is believed that the 675°F data have an error at least twice that of the 575 and 625°F, or $\pm 10\%$.

Figure 5.18 shows the total concentration of low-boiling degradation products and impurities. The total amounts for the products, impurities, and selected components are listed in Table 5.16. Figure 5.18 does not show a linear increase in degradation products, as was observed for the 625 and 575°F data. This is because of the rapid

FIGURE 5.18 Low-Boiling Degradation and Impurities vs. Time at 625°F

decrease in the two major impurities. Figure 5.19 replots the concentration of these two impurities as a function of time. Figure 5.20 replots the total degradation and impurities with the two major impurities subtracted from the samples.

The result of the above subtraction is a smooth degradation curve for the 675°F data. Two small discontinuities in the data appear to have been caused by unscheduled loop shutdowns at 509 and 914 h. Small amounts of air probably leaked into the loop during these times.

The volatile and pyridine regions are shown in Fig. 5.21. The pyridine region again decreases rapidly to low levels and remains relatively constant. There is a slight increase after air incursions. Any pyridine formed after air incursion would be a byproduct of 2MP degradation. The volatile products decrease before an air incursion and increase afterward. This increase is expected because of the volatile oxidation products formed.

Acetamide was first observed at low concentration at 625°F. At 675°F, it immediately reached a concentration in excess of 400 ppm and then increased only slowly. This suggests that it was initially formed from one of the two major impurities in the starting material, after which it was formed more slowly from 2MP degradation. Some n-ethyl acetamide was also formed, but in much lower concentration; it increased linearly throughout the temperatures studied. Both components are plotted as a function of time in Fig. 5.22.

Because of column degradation, it was not possible to resolve the acetic acid and formic acid degradation products from the greatly elevated concentrations of polyalkyl-substituted pyridines. The two regions are combined as one entity to aid in the understanding of total low-boiling degradation. Because of this, it is not possible to present data on the total amount of polyalkyl-substituted pyridines formed. The C2-pyridine identified at 575 and 625°F and used as an internal standard could be identified and quantified. The results for the three temperatures studied are plotted in Fig. 5.23. The concentration of this degradation product decreases as temperature

TABLE 5.16 Concentrations (ppm) of 2-Methylpyridine Degradation Products at 675°F

Time (h)	Volatiles	PYR Region	4-Methyl Pyridine	C2-Pyr P310	N-Et Acet	Acet-amide	Total	Impurities (2)	Total Minus Impurities
0	134	595	2291	0	0.4	0.2	25945	22146	3799
22	179	168	2876	59	17	435	12453	5863	6590
191	449	152	939	112	52	393	12244	2061	10183
359	253	57	855	127	72	572	12718	1104	11614
513	279	105	1197	130	78	502	11844	956	10888
532	652	167	985	131	79	542	12483	916	11567
678	815	194	1484	138	87	469	12971	781	12190
850	535	141	1667	134	95	487	12813	645	12168
920	609	144	1174	117	83	574	13950	590	13360
992	1188	103	2062	137	102	477	14218	645	13573

FIGURE 5.19 Low-Boiling Degradation of Two Impurities vs. Time at 675°F

FIGURE 5.20 Low-Boiling Degradation vs. Time at 675°F with the Two Impurities Subtracted

FIGURE 5.21 Low-Boiling Degradation of Two Components vs. Time at 675°F

FIGURE 5.22 Low-Boiling Degradation of Two Components vs. Time at 675°F

FIGURE 5.23 Low-Boiling Degradation Products vs. Time and Temperature

increases. This indicates that at higher temperatures, this product is less stable and degrades further. At each temperature, there is a leveling of concentration, most pronounced at 675°F (which also indicates that at higher temperature, this component itself degrades more rapidly).

5.4 VAPOR-PHASE ANALYSIS

This section contains the data for all vapor phase samples removed at 575, 625, and 675°F. The concentrations are given in mol % to facilitate comparison of the relative concentrations of the components within the loop. Care must be taken in interpreting data from one sample to another. Initial high values for a component may represent the same number of grams of component as a subsequent low value. For example, helium, used to purge the entire system, is present in high (mol %) concentration initially. As the 2-methylpyridine degrades, other gases are evolved and dilute the helium, thereby lowering the mol % of helium in the sample. Although the helium values are represented by a lower mol % due to dilution, they still represent the same number of grams of helium.

5.4.1 Hydrogen

Clearly, the predominant degradation product is hydrogen gas (H_2). It is produced by bond cleavage to form a hydrogen radical and a 2-methylpyridinyl radical. Subsequently, the two hydrogen radicals combine to form hydrogen. The H_2 concentration increases rapidly to greater than 50% of the total. Data for H_2 are listed in Table 5.17. As expected, more H_2 is produced at higher temperatures than at lower temperatures. The concentration of H_2 is 7.8, 17.1, and 49.7 mol % at 575, 625, and 675°F, respectively, in the first day of loop operation. This increases to almost 90% at 1153 h at 625°F.

Figure 5.24 shows the H_2 concentration as a function of time at the three temperatures studied. The concentrations increase rapidly and then level out. This leveling effect is a consequence of the formation of other degradation products. In the case of the 675°F data, there is a sharp drop in H_2 concentration at 678 h. This is due to a purge required because of the high condenser pressure, which is caused by the rapidly increasing H_2 concentration. The other decrease at this temperature was also due to a system purge. The purge removes the more volatile gases and leaves a relatively higher concentration of the less volatile gases.

The relative drop in concentration at 575°F (497 h) was unexpected. This sample was removed before the completion of the test. The 531-h sample was removed after completion of the test. The H_2 concentration is lower for the 531-h sample than for the 497-h sample because the H_2 diffused into other parts of the loop after shutdown.

5.4.2 Methane

After hydrogen, the next most common degradation product was methane. At 575 and 625°F, only 1-2% of the sample was methane, but this increased to over 12% at 675°F. This large increase had the effect of diluting the hydrogen concentration at this temperature. Table 5.17 lists the methane concentrations for all of the samples.

The large increase in methane concentration at 675°F would be due to the cleavage of the bond between the methyl carbon and the aromatic ring to form methyl and pyridyl radicals. The methyl radical reacts with a hydrogen radical to form methane. The pyridyl radical could react with a hydrogen radical to form pyridine or with another 2-methylpyridine to form C1-bipyridene. The fact that the activation energy of this bond has been reached means that an additional mechanism of degradation, one that significantly increases the degradation rate, is taking place.

Figure 5.25 shows the methane data at each time, plotted by temperature. The very high values clearly reflect the new mode of degradation at 675°F. (Only minor amounts were formed at 575 and 625°F.) The sudden decrease at 678 h and the minor decrease at 850 h are due to the purge of the system. The cause of the minor decrease at 514 h is not known; it may have been related to pressure oscillations preceding an unplanned shutdown.

TABLE 5.17 Vapor-Phase Concentrations (mol %) of Hydrogen and Alkanes

Temp. (°F)	Time (h)	Hydrogen	Methane	C2-alk ^a	C3-alk ^a	C4-alk ^a
575	18	7.8	0.6	0.7	0.6	0.1
	161	70.9	2.6	2.7	1.5	0.7
	328	74.8	2	2.8	1.5	1.7
	497	56.8	2	2.9	5.1	9.4
	531	35.8	1.5	3.5	3.4	10.6
625	21	17.1	0.8	0.3	0.7	0
	189	60.3	1.6	0.4	0.7	0.4
	359	56.2	2.5	1.3	2.7	6.5
	525	78.8	1.6	1.1	2.3	2.6
	694	85.6	1.4	0.8	1.8	1.3
	837	84.5	1.4	0.8	2	2
	1153	86.6	1.4	0.2	1.2	1.3
675	22	49.7	8.4	8.3	1.4	2.3
	191	64.6	15	1.5	0.9	1.3
	359	61.2	17.3	2	1.4	4.2
	514	65.9	13.2	1	2.3	2.9
	532	62.6	12.1	0.9	1.5	3.4
	678	10.1	4.6	4.5	4.8	36
	850	69.8	12.4	1	0.9	3.5
	993	60.7	12.2	1.7	2	5.7

^aAlkanes identified by the number of carbon atoms.

FIGURE 5.24 Hydrogen Concentration vs. Time, at Different Temperatures

FIGURE 5.25 Methane Concentration vs. Time, at Different Temperatures

5.4.3 Other Gaseous Degradation Products

Small quantities of C2-C4 alkanes and alkenes were formed. At 675°F, some C_2H_3N , the only nitrogen-bearing gaseous fragment found, was also detected. The low concentration of these products shows that the activation energy for ring cleavage had not been reached, although the greatly increasing concentration of these degradation products indicates that the activation temperature was near. The working liquid cannot be used successfully in an ORC engine above the activation energy for ring cleavage because of the greatly increased degradation rate.

The degradation products and their concentrations are listed in Table 5.18. The alkenes are usually in slightly greater concentration than the corresponding alkanes: propene (C_3H_6) is in higher concentration than propane (C_3H_8), and butene (C_4H_8) is in higher concentration than both butane (C_4H_{10}) and butadiene (C_4H_6). However, ethane (C_2H_6) is in higher concentration than ethene (C_2H_4). Ethane can be formed from the reaction of two methyl radicals with each other. All the other alkanes are formed by hydrogenation of the corresponding alkene.

Figures 5.26-28 show the total amount of C2, C3, and C4 formed at 575, 625, and 675°F, respectively. (C2 represents the sum of ethane and ethene formed. C3 represents the sum of propane and propene formed. C4 represents the sum of butane, butene, and butadiene formed.) The data are plotted throughout the entire run at each temperature. C2 predominated before 497 h at 575°F, C3 at 625°F, and C4 at 675°F. The large spike of C4 at 625°F is unexplained. However, the large spike of C4 at 675°F was due to the system purge. This purge removed greater amounts of the more volatile hydrogen and methane than of the much less volatile butanes. In general, the concentration of each of these components is less than 4% of the total.

The sum of saturated alkanes (ethane, propane, butane) and unsaturated alkenes (ethene, propene, butenes, and butadiene) is plotted at each of the three temperatures in Figs. 5.29-5.31. The quantities of saturated and unsaturated components were roughly equal at 575°F until the loop shut down because of condenser pressure oscillations. At 625 and 675°F, the preponderance of unsaturated degradation products over saturated ones is evident. Saturated alkanes would be formed from hydrogenation of the

TABLE 5.18 Vapor-Phase Concentrations (mol %) of C2-Amines and Low-Molecular-Weight Hydrocarbons

Temp. (°F)	Time (h)	C ₂ H ₃ N	C ₂ H ₄	C ₂ H ₆	C ₃ H ₆	C ₃ H ₈	C ₄ H ₆	C ₄ H ₈	C ₄ H ₁₀	C ₅ H ₁₀
575	18	0	0.3	0.4	0.2	0.4	0	0.1	0	0.04
	161	0	0.7	2	0.6	0.9	0	0.7	0	0.5
	328	0	0.7	2.1	0.9	0.6	0	1.4	0.3	1
	497	0	0.9	2	3.6	1.5	1.3	6.4	1.7	6
	531	0	0	3.5	2.4	1	1.6	8.2	0.8	7.2
625	21	0	0	0.3	0.3	0.4	0	0	0	0
	189	0	0	0.4	0.3	0.4	0	0.4	0	0.3
	359	0	0	1.3	2.4	0.3	1.1	3.9	1.5	4.3
	525	0	0	1.1	1.9	0.4	0.5	2.1	0	1.4
	694	0	0	0.8	1.4	0.4	0.4	0.9	0	0.7
	837	0	0	0.8	1.5	0.5	0.5	1.5	0	0.8
	1153	0	0	0.8	1	0.2	0.2	1.1	0	0.6
675	22	7	0.3	1	1.2	0.2	1	1.3	0	0.3
	191	0.6	0.2	0.7	0.6	0.3	0.4	0.9	0	0.2
	359	0.6	0.2	1.2	1	0.4	0.8	3.4	0	0.5
	514	0	0.1	0.9	1.9	0.4	0.4	2.5	0	0.2
	532	0	0	0.9	1.2	0.3	0.5	2.9	0	0.3
	678	2.7	0.5	1.3	1.8	3	6.8	29	0.2	2.8
	850	1.3	0.3	0.7	0.6	0.3	0.6	2.6	0.3	0.2
	993	1	0	0.7	1.4	0.6	0.8	4.8	0.1	0.2

FIGURE 5.26 Concentrations of Short-Chain Hydrocarbons vs. Time at 575°F

FIGURE 5.27 Concentrations of Short-Chain Hydrocarbons vs. Time at 625°F

FIGURE 5.28 Concentrations of Short-Chain Hydrocarbons vs. Time at 675°F

FIGURE 5.29 Concentrations of Two Hydrocarbons vs. Time at 575°F

FIGURE 5.30 Concentrations of Two Hydrocarbons vs. Time at 625°F

FIGURE 5.31 Concentrations of Two Hydrocarbons vs. Time at 675°F

unsaturated ones after ring cleavage. The saturated alkanes are more thermodynamically stable, but kinetically the alkenes predominate.

The total concentrations of all C2-C5 alkanes and alkenes for each temperature studied are presented in Figs. 5.32 and 5.33 for the entire loop time. The C5 alkane included in these figures is C_5H_{10} (cyclopentane). The values are relatively stable, and the concentrations are low. The values rise only in association with the loop shutdown at 500 h for the 575°F samples and after a purge at 678 h for the 675°F sample, which preferentially removed the more volatile gaseous products.

In addition to the alkanes and alkenes mentioned above, small quantities of methyl cyclopentane, pentene, and benzene were formed. These larger molecules are always in very low concentration. Their values are included in Table 5.19. Also included in Table 5.19 are the values for saturated alkanes (C2-C4), unsaturated alkanes (alkenes - C2-C4) and all alkanes (including methane).

FIGURE 5.32 Concentrations of C2 to C5 Alkanes vs. Time and Temperature

FIGURE 5.33 Concentrations of C2 to C5 Alkenes vs. Time and Temperature

5.4.4 Background Gases

Background gases fall into three classes. The most important class contains oxidation products from air incursion into the loop, such as carbon monoxide (CO) and carbon dioxide (CO₂). There are also background gases that consist of water (H₂O, a component of the fluid tested), nitrogen (N₂), and oxygen (O₂). Finally, there are the gases present only because they are used to flush and leak-test the equipment, such as helium (He) and argon (Ar). Table 5.20 lists the concentrations of all these gases for the temperatures studied.

The mass spectrometer used in this project was unable to differentiate between N₂ and CO, both of which have mass numbers (M/e) of 28. The source of the N₂ cannot be readily determined, but it may be due to either air incursion or degradation of methylpyridine.

For the 575 and 625°F samples, the concentration of CO₂, initially very low, remains low until the loop shutdown at 500 h, 575°F. Quantities of CO₂ for the 675°F samples were consistently high and decreased only after the loop was purged. The

TABLE 5.19 Vapor-Phase Concentrations (mol %) of Various Degradation Products of 2-Methylpyridine

Temp. (°F)	Time (h)	HC ^a	Sat. ^b	Unsat. ^c	Arom. ^d	Benzene	2-methyl- pyridine	CH ₃ C ₅ H ₉	Acetone
575	18	2.04	0.8	0.6	0.06	0.03	0.03	0	0
	161	8.0	2.9	2	0.1	0.05	0.05	0	0
	328	9.0	3.0	3.0	0.17	0.1	0.07	0	0
	497	25.4	5.2	12.2	0.53	0.5	0.03	0	0
	531	26.2	5.3	12.2	0.18	0.12	0.06	0	0
625	21	1.8	0.7	0.3	0.05	0.05	0	0	0
	189	3.4	0.8	0.7	0.04	0.02	0.02	0	0
	359	17.8	3.1	7.4	0.11	0.08	0.03	0.5	0
	525	9.3	1.5	4.5	0.05	0.03	0.02	0.3	0
	694	6.3	1.2	2.7	0.02	0.02	0	0.3	0
	837	7.4	1.3	3.5	0.02	0.02	0	0.4	0
	1153	5.5	1	2.3	0.02	0.02	0	0.2	0
675	22	13.8	1.2	3.8	0.07	0.05	0.02	0.1	0
	191	18.4	1	2.1	0	0	0	0.1	0
	359	25	1.6	5.4	0.02	0.02	0	0.2	0
	514	19.7	1.3	4.9	0.01	0.01	0	0.1	0
	532	18.4	1.2	4.6	0.01	0.01	0	0.2	0
	678	52.9	4.5	38.1	1.4	0.2	1.2	2.9	0.8
	850	18.3	1.3	4.1	0.02	0.02	0	0.3	0.3
	915	17.5	1.6	5.9	0.3	0.3	0	0.5	4.3
	921	19.8	1.6	7.3	0.02	0.02	0	0.4	0.5
	993	21.3	1.4	7	0.02	0.02	0	0.5	0.8

^aHC = all hydrocarbons, including methane, alkanes, alkenes, aromatics, acetone.

^bSat. = all saturated alkanes except methane.

^cUnsat. = all alkenes except C₅H₁₀ and CH₃C₅H₉.

^dArom. = aromatics (methylpyridine and benzene).

TABLE 5.20 Vapor-Phase Concentrations (mol %) of Background Gases for 2-Methylpyridine

Temp. (°F)	Time (h)	CO ₂	N ₂ + CO	O ₂	H ₂ O	He	Ar
575	18	1.1	2	0.01	0.2	86.8	0.01
	161	4.7	10.2	0.01	0.2	5.9	0.01
	328	7.9	5.6	0.02	0.3	2.2	0
	497	12.1	4	0.05	0.04	1.1	0
	531	21.7	10.3	0.9	0.04	4.8	0
625	21	1.1	1.9	0.01	0.05	78	0
	189	2.2	8.7	0.2	0.05	25.1	0
	359	7.9	14.7	0.04	0.9	2.4	0
	525	6.2	4.8	0.01	0.08	0.8	0
	694	3.5	3.6	0.02	0.02	0.9	0
	837	3	3.8	0.02	0.03	1.3	0
	1153	2.6	3	0.02	0.06	2.2	0
675	22	10.6	18.7	0.02	0.02	0.12	0
	191	11.5	5	0.01	0.02	0.02	0
	359	7.9	5.1	0.01	0.05	0.03	0
	514	9.9	4.3	0.01	0.04	0.03	0
	532	14.4	4.4	0.02	0.03	0.02	0.01
	678	16.2	7	0.04	8.9	0	0
	850	6	4.1	0.13	0.03	0	0
	993	9	7.1	0.01	0.03	0	0

combined N₂ and CO values were more variable. Normal values appear to be in the 3 to 5 mol % range. Large variations were expected around unscheduled loop shutdowns or system purges; however, there were also unexplained variations, such as the spike at 359 h, 625°F. Figures 5.34-36 plot the concentration of CO₂ and the combined N₂ and CO concentration at 575, 625, and 675°F, respectively.

Oxygen values were consistently low. This was expected, because oxygen formed either from the water present or due to air incursion would immediately react with the fluid to form carbonyls, CO, and CO₂. The acetone (Table 5.14) formed after the loop shutdown at 520 h, 675°F was probably due to air incursion. There was a corresponding increase in CO₂ concentration at this time.

The water concentration was low. Water was present in the working fluid, but its vapor pressure was sufficiently low that it was normally less than 0.1% of the total. Only one sample contained a significant amount of H₂O. This was the purge sample at 678 h and 675°F, which gave very different results from the other samples.

FIGURE 5.34 Concentrations of Two Components vs. Time at 575°F

FIGURE 5.35 Concentrations of Two Components vs. Time at 625°F

FIGURE 5.36 Concentrations of Two Components vs. Time at 675°F

Helium and argon were used for purging the system and for leak testing. Helium appeared initially in high concentration at 575 and 625°F and then became diluted as degradation products formed. The argon was always in low concentration.

5.5 DETERMINATION OF DEGRADATION RATES

In this section, degradation in the high- and low-boiling regions is totaled. The totals, shown in Tables 5.21-5.23, include all degradation and impurities (except that the two major impurities in the 675°F run are not included in the totals of Table 5.23). As the tables show, degradation in the low-boiling region, where ring cleavage is the prevalent degradation reaction, greatly exceeds degradation in the high-boiling region, where dimerization is the prevalent degradation reaction.

TABLE 5.21 Total Degradation (ppm) for High- and Low-Boiling Components at 575°F

Type of Component	0 h	18 h	161 h	328 h	532 h
High-Boiling	1	282	241	337	350
Low-Boiling	4438	4119	4576	4856	5593
Total	4439	4401	4817	5193	5943

TABLE 5.22 Total Degradation (ppm) for High- and Low-Boiling Components at 625°F

Type of Component	0 h	20 h	188 h	358 h	525 h	693 h	836 h	1153 h
High-Boiling	1	203	595	669	881	913	1316	1459
Low-Boiling	4438	4286	5095	5192	5445	5475	5637	5873
Total	4439	4489	5690	5861	6326	6388	6953	7332

TABLE 5.23 Total Degradation (ppm) for High- and Low-Boiling Components at 675°F

Type of Component	0 h	22 h	191 h	359 h	524 h	532 h	678 h	850 h	921 h	993 h
High-Boiling	76	264	513	720	726	841	1010	1091	878	982
Low-Boiling ^a	3799	6590	10183	11614	10888	11567	12190	12168	13360	13573
Total	3875	6854	10696	12334	11614	12408	13200	13259	14238	14555

^aAmounts of two major impurities have been subtracted from the total for low boilers.

The totals were plotted in Fig. 5.37-39, and a linear least-squares analysis was applied to the data. The slopes of the lines thus obtained are the degradation rates. As the figures show, a linear degradation rate describes the 575 and 625°F data reasonably well, but the 675°F data indicate a very rapid increase in degradation followed by a slower and roughly linear increase. Therefore, two separate lines were fitted to the 675°F data. The first (with slope = 7.368 ppm/h) excludes the 0-h initial material point, and the second (with slope = 4.313 ppm/h) excludes both the 0-h and the 22-h data. All points were included in the 575 and 625°F least-squares fits. There were two unscheduled shutdowns of the loop during the 675°F run at 509 and 914 h. Although there is evidence that small air incursions occurred while the loop was down, these air incursions appear to have little effect on the totals; the scatter in the data is at least as large as any effect that could be attributed to air incursions. The primary effect of an air incursion is to alter the ratios between amounts of individual components of degradation, without having much effect on the total.

Degradation rates for the three runs are summarized in Table 5.24. The degradation rate for the 575°F run exceeds the degradation rate for the 625°F run. Two effects may explain this. The first is scatter in the data; the second is that 2MP at 575°F and 625°F, as at 675°F, may tend to degrade rapidly during the first 100 h and more slowly thereafter. Because the 575°F test ran only 532 h and the 625°F test ran 1153 h, such an effect would tend to increase the calculated degradation rate for the 575°F test relative to that of the 625°F test. To check this hypothesis, the degradation rate for the 625°F test was recomputed using only the 0- to 525-h data. The recomputed degradation rate is 3.6 ppm/h. From this analysis, 2MP appears to have a rapid initial degradation rate followed by a slower rate.

FIGURE 5.37 Total Degradation vs. Time at 575°F

FIGURE 5.38 Total Degradation vs. Time at 625°F

FIGURE 5.39 Total Degradation vs. Time at 675°F

TABLE 5.24. Summary of Degradation Rates

Run No.	Temp. (°F)	Degradation Rate (ppm/h)
1	575	2.8
2	625	2.5
3	675	4.3-7.4

6 CONCLUSIONS AND RECOMMENDATIONS

Of the three ORC fluids we have tested in our dynamic test loops, 2-methylpyridine/water is the least stable. We measured a degradation rate of 2.8 ppm/h for 2-methylpyridine/water at 575°F. For comparison, we measured 1.8 ppm/h for Fluorinol 85 at the same temperature and 0.11 ppm/h for toluene at 600°F. If an ORC engine had the same fraction of its fluid in the evaporator as our dynamic loop has, annual degradation with 2-methylpyridine/water under test conditions would amount to about 2.5%. Degradation at 625°F would be similar; at 675°F, however, annual degradation would increase to 3.8-6.5%. Moreover, we have observed rapid evolution of hydrogen, which tended to make loop operation unstable.

Ring cleavage is the most important degradation mechanism. The presence of a nitrogen atom weakens the ring. Ring cleavage leads formation of to a variety of low-molecular-weight degradation products. Dimerization is another important degradation mechanism, albeit less so than ring cleavage. Hydrolization of the ring-cleavage products leads to formation of acetic and formic acids. The formation of acids is noteworthy, even though these are not strong acids. Many other secondary reactions also occur between degradation products, impurities, and 2-methylpyridine. If oxygen enters the system, it will react with the 2-methylpyridine. However, it is difficult to distinguish these oxygen-bearing degradation products from those derived from a reaction with water.

Hydrogen is the main gaseous degradation product. At temperatures up to 625°F, its rate of formation was managable, but at 675°F sufficient hydrogen was formed to require purging it from the condenser. The rapid formation of hydrogen tended to make the loop run with less stability. In an ORC engine, a cold trap would be necessary to remove hydrogen from the condenser.

We recommend that other fluids be chosen for ORC system use in preference to 2-methylpyridine/water. (Toluene, for example, would be a good choice.) If 2-methylpyridine/water is chosen for ORC service, we recommend a maximum engine temperature no higher than 625°F (preferably, no higher than 575°F). The 2-methylpyridine/water fluid has other characteristics that are undesirable. Its toxicity is greater than that of either Fluorinol 85 or toluene. It has an exceedingly unpleasant, lingering odor. Finally, 2-methylpyridine degrades, albeit slowly, at room temperature in sealed containers kept away from light. The 2-methylpyridine/water thus presents handling problems that other fluids do not have.

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APPENDIX A:**DAILY AVERAGES, MINIMA, AND MAXIMA OF EVAPORATOR TEMPERATURE,
EVAPORATOR PRESSURE, AND CONDENSER PRESSURE**

The data provided in this appendix are 24-hour averages, minima, and maxima of the evaporator temperature, evaporator pressure, and condenser pressure compiled from data taken each half hour during the test runs. The purpose of the data provided herein is to verify the accuracy with which the loop parameters were maintained. Since the evaporator temperature and pressure affect the temperature distribution in the hot parts of the loop, they are the most important indicators of how well the loop is controlled. Condenser pressure is included because, if it becomes subatmospheric, air could leak into the loop. Any oxygen in the loop reacts immediately with 2-methylpyridine to form degradation products.

**TABLE A.1 Summary of Temperatures and Pressures at Daily Intervals for Test No. 1
(575°F)**

Interval (h)	Evaporator Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
0-8	562.0	535.3	568.0	493.47	473.00	515.70	17.93	17.70	18.19
8-32	571.8	565.2	576.7	495.31	480.50	508.90	17.95	17.83	18.28
32-56	575.2	574.2	576.0	495.05	479.60	512.50	17.96	17.77	18.12
56-80	574.7	574.2	575.2	493.01	475.40	506.80	17.94	17.78	18.09
80-104	574.5	573.9	575.0	496.19	480.90	510.80	17.97	17.82	18.16
104-128	573.2	568.1	575.2	493.35	479.60	511.20	17.95	17.84	18.06
128-152	574.4	574.0	575.0	494.44	481.10	505.40	17.96	17.81	18.06
152-176	574.9	574.0	576.4	495.70	484.10	508.50	17.96	17.84	18.11
176-200	575.3	574.7	576.2	495.39	474.20	512.60	17.98	17.86	18.23
200-224	575.1	574.4	575.7	492.00	469.60	511.60	17.91	17.73	18.10
224-248	574.9	574.1	575.6	498.84	485.20	512.70	17.98	17.67	18.24
248-272	574.8	574.2	575.2	494.49	480.90	504.90	17.94	17.80	18.05
272-296	574.7	574.1	575.2	495.73	482.40	506.50	17.96	17.83	18.08
296-320	574.6	574.0	575.2	497.04	482.70	514.90	17.96	17.74	18.13
320-344	574.8	574.1	576.0	496.31	481.50	516.50	17.99	17.80	18.72
344-368	575.0	574.3	575.9	493.76	474.60	509.20	17.96	17.54	18.28
368-392	575.1	574.3	576.3	494.44	475.40	511.40	17.96	17.72	18.16
392-416	575.0	574.3	575.6	495.61	480.30	521.90	17.97	17.78	18.15
416-440	574.9	574.1	575.7	497.13	479.00	512.40	17.97	17.80	18.11
440-464	574.9	573.9	575.5	495.48	478.70	516.80	17.96	17.68	18.17
464-488	575.0	574.3	575.9	493.63	476.90	509.20	17.98	17.80	18.24
488-512	575.3	574.2	576.2	492.53	473.00	513.50	17.96	17.78	18.11
512-532	579.1	574.8	612.8	486.40	445.50	513.00	17.97	17.81	18.10
Overall	574.7	535.3	612.8	494.67	445.50	521.90	17.96	17.54	18.72

TABLE A.2 Summary of Temperatures and Pressures at Daily Intervals for Test No. 2 (625°F)

Interval (h)	Evaporator Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
0-11	621.3	619.7	624.5	496.43	488.00	502.50	18.02	17.14	18.84
11-35	624.6	617.7	629.9	499.33	489.80	510.90	18.24	17.23	19.07
35-59	628.0	626.0	629.2	499.66	488.70	511.60	18.08	16.77	18.80
59-83	625.6	621.2	628.1	502.05	493.00	511.00	18.09	17.05	19.38
83-107	623.5	620.8	625.6	498.66	490.90	511.50	18.06	17.06	19.04
107-131	625.1	624.2	626.1	500.36	490.10	513.60	18.03	17.17	19.04
131-155	624.7	620.6	626.6	500.60	491.80	510.00	18.21	17.29	18.92
155-179	623.6	619.7	626.3	500.64	488.80	512.40	17.99	17.15	18.81
179-203	624.1	622.0	625.9	499.83	491.10	511.20	17.98	17.25	19.08
203-227	625.4	624.0	627.3	498.74	490.10	512.50	18.10	17.27	19.10
227-251	625.4	623.7	626.9	502.49	489.40	509.10	18.02	17.22	18.98
251-275	625.6	624.0	627.3	501.69	489.10	509.10	18.12	17.34	19.13
275-299	625.4	624.0	627.0	497.95	492.00	507.30	18.08	17.16	18.85
299-323	625.2	624.1	626.3	500.72	493.30	507.70	18.08	17.26	19.16
323-347	625.1	623.7	626.3	495.66	486.60	501.50	18.19	17.16	19.20
347-371	624.9	623.9	625.9	498.98	488.70	506.70	18.08	17.05	18.93
371-395	625.0	623.2	626.2	499.27	488.90	509.10	18.04	17.65	18.58
395-419	625.2	623.3	626.7	502.13	493.60	509.40	18.06	17.48	18.65
419-443	624.5	623.3	625.6	501.83	491.50	509.40	18.04	17.21	19.12
443-467	624.1	622.2	624.9	500.11	489.80	508.20	18.29	17.38	19.20
467-491	623.9	622.8	625.1	497.64	488.00	507.10	17.87	16.73	19.23
491-515	624.3	622.8	626.1	492.85	486.50	507.40	18.15	16.97	19.12
515-539	624.7	621.8	626.3	503.20	490.00	510.80	18.17	17.44	19.29
539-563	624.9	623.7	626.0	498.08	486.90	509.10	18.06	17.19	18.94
563-587	625.2	624.3	626.2	501.32	488.00	511.90	18.02	16.99	18.92
587-611	625.2	619.8	626.2	497.87	486.50	504.90	18.11	16.92	19.09
611-635	623.8	620.8	626.7	497.58	487.90	510.90	18.25	17.02	19.32

TABLE A.2 (Cont'd)

Interval (h)	Evaporator Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
635-659	624.5	622.4	625.8	499.04	487.60	506.10	18.16	16.92	19.32
659-683	624.5	623.8	625.3	500.88	490.30	506.00	18.11	16.91	19.21
683-707	624.2	623.4	625.0	500.15	489.30	506.20	17.99	16.97	18.91
707-731	624.7	623.8	625.4	503.20	494.30	507.00	18.07	17.25	19.22
731-755	624.5	623.3	625.6	500.33	469.90	509.90	18.14	17.20	19.33
755-779	624.9	622.9	626.8	499.18	475.50	507.80	18.11	17.06	19.36
779-803	624.7	622.6	626.4	503.16	480.00	510.20	18.21	17.01	18.98
803-827	625.2	624.3	626.3	500.50	492.30	505.50	18.09	17.10	18.87
827-851	624.9	623.2	625.9	503.81	491.90	508.10	18.05	17.26	18.84
851-875	624.6	622.3	626.3	501.46	485.30	508.60	17.92	17.09	18.96
875-899	624.5	622.2	626.2	498.54	487.70	510.70	18.14	17.29	18.94
899-923	625.0	623.4	626.5	499.42	478.50	510.30	18.06	16.96	18.93
923-947	625.1	623.0	625.9	500.07	488.60	507.10	18.09	17.10	18.81
947-971	624.3	619.9	627.1	500.61	489.40	510.90	18.14	17.29	18.91
971-995	622.9	620.9	624.8	498.85	483.40	516.30	18.04	17.13	18.90
995-1019	625.2	624.0	625.8	496.22	485.70	506.40	18.07	17.27	18.83
1019-1043	622.8	619.3	626.1	499.66	487.50	508.10	18.16	17.45	19.14
1043-1067	620.4	618.0	622.1	496.28	483.10	509.20	18.15	17.25	19.02
1067-1091	620.5	617.6	622.1	499.26	486.70	509.60	18.00	17.29	19.04
1091-1115	619.9	618.5	621.1	498.12	475.90	509.00	18.11	17.42	18.79
1115-1139	620.3	618.3	621.1	498.47	489.20	506.90	18.19	17.42	18.88
1139-1153	620.7	619.6	621.9	497.66	490.40	506.10	17.96	16.89	18.90
Overall	624.3	617.6	629.9	499.66	469.90	516.30	18.09	16.73	19.38

TABLE A.3 Summary of Temperatures and Pressures at Daily Intervals for Test No. 3 (675°F)

Interval (h)	Evaporator Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
0-12	667.0	643.9	671.2	502.80	492.70	513.10	17.73	17.05	18.14
12-36	673.5	669.7	676.5	499.44	482.20	511.90	17.60	16.98	18.33
36-60	674.6	672.6	676.0	499.08	481.00	513.80	17.72	16.91	18.87
60-84	672.5	671.1	673.6	496.82	483.20	508.90	17.67	16.75	18.55
84-108	672.0	670.1	673.5	498.12	485.40	511.30	17.74	16.96	18.56
108-132	671.7	669.6	672.9	498.39	486.80	511.70	17.70	16.94	18.75
132-156	674.4	669.4	679.1	494.46	480.20	505.40	17.72	16.98	18.75
156-180	677.7	677.0	679.1	501.27	492.80	510.00	17.67	16.95	18.54
180-204	677.2	676.0	678.6	500.30	480.30	516.60	17.77	16.34	18.74
204-228	677.8	676.6	678.9	502.66	493.50	510.10	17.63	17.02	18.23
228-252	679.4	677.7	681.2	498.10	483.10	508.90	17.74	17.09	18.52
252-276	679.4	676.8	681.7	497.80	484.00	508.50	18.28	17.21	20.39
276-300	676.6	672.9	680.1	498.61	477.50	514.10	18.64	17.18	20.65
300-324	675.0	673.3	676.8	500.90	486.80	512.50	17.66	16.73	18.57
324-348	674.3	672.9	675.1	500.93	484.10	511.60	17.76	16.66	18.43
348-372	674.4	673.3	675.8	501.15	485.30	511.70	17.83	16.77	18.70
372-396	675.6	674.8	676.6	502.44	491.00	512.00	17.74	16.81	18.72
396-420	674.9	673.1	676.1	497.75	482.60	510.20	17.76	16.73	18.51
420-444	674.1	673.0	674.9	499.76	481.50	511.50	17.75	16.81	18.52
444-468	673.7	672.8	674.6	498.30	483.70	510.40	17.72	16.63	18.41
468-492	674.2	673.0	675.6	501.61	481.90	512.80	17.70	17.05	18.43
492-509 ^a	675.1	674.3	675.7	505.48	483.50	563.10	17.53	16.97	18.21
509-523	673.5	652.7	677.2	499.03	482.10	510.70	17.79	16.24	18.88
523-547	674.2	673.4	674.8	496.07	481.60	506.40	17.69	16.71	18.47
547-571	675.0	673.9	676.0	500.38	477.80	514.80	17.72	16.87	18.72
571-595	674.4	673.5	675.3	500.19	484.40	513.20	17.67	17.05	18.36
595-619	674.6	673.2	675.6	501.19	489.20	513.40	17.68	17.05	18.51

TABLE A.3 (Cont'd)

Interval (h)	Evaporator Temperature (°F)			Evaporator Pressure (psia)			Condenser Pressure (psia)		
	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.
619-643	674.9	673.4	675.7	499.22	483.30	509.60	17.66	17.20	18.29
643-667	674.7	671.7	675.6	504.70	497.20	511.00	17.71	17.21	18.24
667-691	675.8	673.5	677.4	504.05	488.80	511.10	17.71	17.21	18.35
691-715	677.6	676.5	678.3	504.08	485.70	512.70	17.68	17.46	17.93
715-739	677.2	676.1	678.2	498.23	480.10	506.30	17.68	17.29	17.96
739-763	675.6	674.1	676.8	499.47	481.10	510.80	17.67	17.30	18.05
763-787	675.6	673.7	677.4	499.53	484.20	511.50	17.64	17.19	18.01
787-811	674.9	655.3	677.0	497.76	488.70	509.70	17.64	17.12	18.13
811-835	674.9	673.1	676.5	498.32	486.00	507.80	17.72	17.20	18.29
835-859	674.4	672.1	677.3	492.44	479.90	510.40	17.71	17.04	18.49
859-883	676.6	675.8	677.4	499.46	485.80	511.80	17.72	17.34	18.18
883-907	677.2	676.4	677.8	503.15	454.30	510.80	17.64	17.19	18.06
907-914 ^b	676.3	676.2	676.6	509.23	489.20	579.40	17.82	17.36	18.29
914-928	673.4	664.0	676.6	495.44	478.80	512.80	17.64	17.12	17.98
928-952	676.0	675.3	677.0	490.64	483.20	503.70	17.61	17.25	18.22
952-976	676.5	675.6	677.5	490.85	484.00	497.30	17.66	17.30	18.17
976-992	676.9	676.1	677.8	499.43	482.40	508.00	17.64	17.15	18.06
Overall	675.2	643.9	681.7	499.32	454.30	579.40	17.73	16.24	20.65

^aLoop down for 18 h at the end of this time period.

^bLoop down for 49 h at the end of this time period.

APPENDIX B:
DEGRADATION REPORT
FOR HIGH BOILERS

Tables B.1-B.22 show the concentration (ppm) of each high-boiling impurity and degradation component and the total concentration (ppm) of all such components. In addition, the tables show the aromatic retention index for each component. Names of major degradation products in Tables B.1-B.22 can be determined by correlating their retention indexes with the retention indexes and names shown in Table 5.2 in this report.

**TABLE B.1 2-Methylpyridine Degradation:
575°F, Initial Material**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	406.1	0.73	15.96	6.9
2	598.6	0.72	34.09	6.8

RI/CONC REPORT

Sample file : P575h000H.001a

COMMENTS : HP Pic initial lul CS no
spike
Initial material for 575
and 625°F

Total concentration : 1.45997 ppm

Total number of peaks interpreted : 2

Peaks rejected before starting retention
time : 50

Peaks rejected after final retention
time : 2

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.2 2-Methylpyridine Degradation:
575°F, 18 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	400.0	50.06	15.33	473.3
2	400.9	189.12	15.42	1788.1
3	405.9	1.61	15.89	15.2
4	406.7	8.49	15.97	80.3
5	409.5	0.68	16.22	6.4
6	415.8	0.69	16.82	6.5
7	418.6	1.17	17.09	11.0
8	419.6	2.20	17.18	20.8
9	421.7	0.62	17.38	5.8
10	429.0	0.73	18.06	6.9
11	432.3	0.54	18.38	5.1
12	433.3	1.36	18.47	12.9
13	434.6	0.82	18.59	7.7
14	438.9	1.28	19.00	12.1
15	441.0	0.68	19.20	6.4
16	445.3	1.05	19.60	9.9
17	459.8	1.77	20.96	16.7
18	461.0	1.30	21.07	12.3
19	470.1	0.56	21.94	5.3
20	471.3	2.03	22.05	19.2
21	477.5	1.34	22.63	12.7
22	537.6	0.66	28.29	6.2
23	539.9	1.49	28.51	14.0
24	544.7	0.76	28.96	7.2
25	550.4	2.54	29.50	19.8
26	553.2	1.74	29.76	13.5
27	561.4	1.05	30.53	8.1
28	568.6	1.66	31.22	12.9
29	655.6	0.62	39.40	5.9
30	665.2	2.36	40.31	22.3

TABLE B.2 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
31	704.1	0.64	43.98	6.1

RI/CONC REPORT

Sample file : P575h018H.001a

COMMENTS : HP Pic 18Hr P2 1ul no spike
CS

Total concentration : 281.8 ppm

Total number of peaks interpreted : 31

Peaks rejected before starting retention
time : 69Peaks rejected after final retention
time : 2^aArea is in a unit that is calibrated when
the standard sample is analyzed.

**TABLE B.3 2-Methylpyridine Degradation:
575°F, 161 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	400.9	67.40	15.40	637.3
2	407.2	2.11	15.99	20.0
3	408.0	6.20	16.06	58.6
4	410.7	0.86	16.32	8.1
5	412.5	3.74	16.48	35.3
6	413.5	1.06	16.58	10.1
7	414.4	1.14	16.67	10.8
8	416.1	10.73	16.83	101.4
9	419.9	24.31	17.18	229.9
10	421.9	2.01	17.37	19.0
11	424.9	4.45	17.65	42.1
12	426.1	1.84	17.76	17.4
13	429.3	1.50	18.06	14.1
14	429.8	1.51	18.12	14.2
15	431.7	2.80	18.30	26.4
16	433.6	6.60	18.47	62.4
17	434.9	10.60	18.60	100.2
18	437.6	6.94	18.85	65.7
19	439.7	2.01	19.05	19.0
20	441.3	3.46	19.20	32.7
21	442.8	0.70	19.34	6.6
22	445.7	3.24	19.61	30.6
23	446.7	0.68	19.71	6.4
24	450.3	3.42	20.04	32.3
25	454.3	0.73	20.42	6.9
26	456.4	1.06	20.62	10.1
27	459.4	3.65	20.90	34.5
28	460.7	1.64	21.03	15.5
29	461.2	4.32	21.07	40.8
30	466.7	0.63	21.59	5.9
31	469.7	2.09	21.87	19.7
32	471.6	3.42	22.06	32.3
33	475.1	2.46	22.38	23.2
34	477.9	2.00	22.64	18.9
35	486.1	0.61	23.42	5.7

TABLE B.3 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	488.4	0.54	23.64	5.1
37	493.4	0.74	24.11	7.0
38	497.1	0.76	24.45	7.2
39	501.5	0.78	24.87	7.4
40	509.1	1.29	25.58	12.2
41	510.8	0.61	25.74	5.8
42	512.8	2.36	25.93	22.3
43	544.9	0.54	28.96	5.1
44	547.4	1.01	29.19	7.8
45	548.6	0.95	29.30	7.4
46	553.5	1.20	29.77	9.3
47	554.7	1.05	29.88	8.1
48	556.9	1.00	30.08	7.8
49	558.9	1.17	30.27	9.1
50	561.6	4.42	30.52	34.4
51	563.9	3.07	30.74	23.9
52	569.0	4.88	31.22	38.0
53	574.1	2.83	31.71	22.0
54	579.3	1.67	32.19	13.0
55	581.7	0.93	32.42	7.2
56	584.8	6.56	32.72	51.0
57	595.9	1.93	33.76	18.2
58	601.7	0.66	34.30	6.3
59	609.5	0.57	35.04	5.4
60	619.7	1.15	36.00	10.9
61	630.8	0.71	37.05	6.7
62	651.2	0.66	38.97	6.3
63	652.1	1.21	39.05	11.4
64	665.7	1.12	40.33	10.6
65	681.3	1.48	41.80	14.0

TABLE B.3 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
66	704.4	0.54	43.97	5.1

RI/CONC REPORT

Sample file : P575h161H.001a

COMMENTS : HP 161 hr P2 1uL CS no
spike

Total concentration : 240.647 ppm

Total number of peaks interpreted : 66

Peaks rejected before starting retention
time : 100Peaks rejected after final retention
time : 2^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.4 2-Methylpyridine Degradation:
575°F, 329 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	400.8	22.38	15.37	211.6
2	405.9	2.36	15.84	22.3
3	407.9	10.13	16.04	95.8
4	411.4	1.21	16.37	11.5
5	412.4	6.61	16.46	62.5
6	413.6	1.41	16.57	13.3
7	416.0	21.32	16.80	201.6
8	419.9	33.92	17.16	320.7
9	422.0	2.78	17.36	26.3
10	424.9	5.54	17.64	52.4
11	426.0	3.06	17.74	28.9
12	429.9	3.31	18.11	31.3
13	431.9	3.70	18.30	35.0
14	433.6	4.87	18.46	46.1
15	435.0	22.10	18.58	209.0
16	437.5	9.58	18.82	90.6
17	439.7	2.65	19.03	25.1
18	441.3	2.74	19.18	25.9
19	442.9	1.81	19.33	17.1
20	445.7	2.22	19.59	21.0
21	447.4	0.77	19.75	7.3
22	450.3	4.70	20.02	44.4
23	452.3	0.99	20.21	9.3
24	454.2	1.33	20.39	12.6
25	456.3	0.95	20.59	8.9
26	459.7	0.94	20.91	8.9
27	461.2	4.06	21.06	38.4
28	464.0	0.73	21.32	6.9
29	466.4	0.53	21.54	5.0
30	469.6	3.94	21.84	37.2
31	471.8	0.62	22.05	5.9
32	474.5	5.64	22.30	53.3
33	482.6	0.82	23.07	7.7
34	486.1	0.79	23.40	7.5
35	488.0	0.82	23.58	7.8

TABLE B.4 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	489.1	1.13	23.68	10.7
37	490.4	0.92	23.81	8.7
38	493.4	2.70	24.08	25.5
39	497.9	0.69	24.51	6.5
40	501.5	1.12	24.84	10.6
41	509.1	1.33	25.57	12.6
42	510.9	2.16	25.74	20.4
43	512.7	4.65	25.91	44.0
44	516.4	1.20	26.25	11.3
45	517.3	0.57	26.34	5.4
46	522.4	0.60	26.81	5.6
47	524.3	0.57	27.00	5.4
48	526.0	0.97	27.16	9.2
49	529.2	2.21	27.46	20.9
50	532.0	0.59	27.72	5.6
51	541.3	1.14	28.60	10.8
52	544.3	0.64	28.88	6.0
53	545.0	0.54	28.95	5.1
54	545.9	0.66	29.03	5.1
55	548.5	1.62	29.27	12.6
56	554.2	0.96	29.81	7.5
57	554.9	2.57	29.87	20.0
58	558.7	2.50	30.23	19.4
59	560.7	0.72	30.42	5.6
60	561.6	5.37	30.51	41.8
61	563.9	3.25	30.73	25.2
62	565.6	2.02	30.88	15.7
63	569.0	4.19	31.21	32.6
64	572.0	6.43	31.49	50.0
65	574.1	9.29	31.68	72.3
66	574.9	7.10	31.76	55.2
67	578.3	0.73	32.09	5.6
68	579.2	4.03	32.17	31.3
69	581.8	2.59	32.41	20.1
70	584.8	17.50	32.70	136.1

TABLE B.4 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	591.9	3.06	33.37	23.8
72	594.3	18.02	33.59	140.1
73	595.8	5.31	33.73	50.2
74	601.7	0.91	34.28	8.6
75	609.5	0.72	35.02	6.8
76	619.6	4.15	35.97	39.3
77	626.4	0.69	36.61	6.5
78	630.7	2.52	37.02	23.8
79	632.6	0.55	37.20	5.2
80	645.6	0.86	38.42	8.2
81	651.9	0.59	39.02	5.6
82	655.3	0.54	39.34	5.1
83	661.4	1.01	39.91	9.6
84	662.6	0.68	40.02	6.4
85	681.3	3.68	41.78	34.8
86	693.1	1.41	42.90	13.4
87	694.4	0.80	43.01	7.6
88	698.1	1.86	43.36	17.5
89	700.9	1.84	43.63	17.4
90	704.5	0.81	43.97	7.7

RI/CONC REPORT

Sample file : P575h329H.001a

COMMENTS : HP 329 hr P2 1ul CS no
spike

Total concentration : 337.033 ppm

Total number of peaks interpreted : 90

Peaks rejected before starting retention
time : 93Peaks rejected after final retention
time : 2^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.5 2-Methylpyridine Degradation:
575°F, 532 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	400.7	2.85	15.37	27.3
2	401.0	2.05	15.40	19.6
3	403.1	3.35	15.59	32.1
4	404.0	2.08	15.68	20.0
5	405.0	1.38	15.78	13.2
6	406.0	1.18	15.87	11.3
7	407.7	17.21	16.03	164.8
8	409.6	1.03	16.21	9.8
9	410.4	2.14	16.28	20.5
10	410.8	4.09	16.32	39.2
11	412.2	8.51	16.45	81.5
12	413.1	3.52	16.54	33.7
13	414.5	4.63	16.67	44.3
14	415.8	27.09	16.79	259.5
15	416.8	5.64	16.89	54.0
16	418.3	2.02	17.03	19.4
17	419.7	32.12	17.16	307.6
18	420.9	4.20	17.27	40.2
19	421.9	2.15	17.36	20.6
20	424.7	5.38	17.63	51.5
21	425.9	1.57	17.74	15.1
22	426.7	0.91	17.81	8.7
23	427.2	0.66	17.86	6.3
24	429.3	5.09	18.06	48.7
25	430.6	2.27	18.19	21.7
26	431.8	3.49	18.30	33.5
27	433.5	4.43	18.46	42.4
28	434.9	26.73	18.59	256.0
29	437.4	7.16	18.83	68.6
30	439.6	1.46	19.04	14.0
31	441.2	1.23	19.18	11.8
32	442.9	1.88	19.34	18.0
33	445.7	1.43	19.60	13.7
34	447.3	1.28	19.75	12.3
35	450.2	3.58	20.03	34.3

TABLE B.5 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	454.1	1.40	20.40	13.4
37	456.1	0.89	20.59	8.6
38	456.8	0.78	20.65	7.5
39	461.3	0.97	21.08	9.3
40	466.2	0.87	21.53	8.3
41	467.8	0.54	21.69	5.2
42	469.5	5.64	21.85	54.0
43	471.8	0.56	22.06	5.4
44	473.8	1.73	22.26	16.6
45	474.7	0.56	22.34	5.4
46	475.4	1.20	22.40	11.4
47	476.3	1.98	22.49	19.0
48	478.1	0.56	22.66	5.3
49	479.9	1.14	22.82	10.9
50	482.5	1.15	23.08	11.0
51	484.9	0.53	23.30	5.0
52	486.1	1.31	23.41	12.5
53	486.7	0.64	23.47	6.1
54	487.9	1.20	23.58	11.4
55	489.0	2.48	23.69	23.8
56	490.4	1.38	23.82	13.2
57	492.8	1.86	24.04	17.9
58	496.5	0.73	24.39	7.0
59	497.9	1.30	24.53	12.4
60	500.0	1.12	24.72	10.7
61	501.4	1.42	24.85	13.6
62	511.0	2.01	25.75	19.2
63	512.7	4.17	25.92	39.9
64	517.1	0.85	26.33	8.1
65	524.4	0.70	27.02	6.7
66	526.0	1.29	27.17	12.3
67	529.2	1.88	27.47	18.0
68	532.0	0.72	27.73	6.9
69	535.8	1.08	28.09	10.4
70	536.8	0.61	28.19	5.9

TABLE B.5 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	538.9	0.67	28.38	6.4
72	541.4	1.60	28.62	15.3
73	544.2	0.96	28.88	9.2
74	545.1	0.73	28.97	7.0
75	545.9	0.73	29.05	5.2
76	548.5	3.82	29.29	27.0
77	550.9	1.02	29.52	7.2
78	554.8	3.56	29.88	25.2
79	556.9	1.80	30.08	12.7
80	557.6	1.02	30.15	7.2
81	558.7	2.44	30.25	17.2
82	559.5	0.85	30.33	6.0
83	561.6	12.54	30.52	88.6
84	563.9	0.78	30.74	5.5
85	566.9	1.21	31.02	8.5
86	568.0	0.90	31.13	6.4
87	569.2	6.35	31.24	44.8
88	572.2	1.72	31.52	12.1
89	574.1	15.67	31.70	110.7
90	579.3	4.16	32.18	29.4
91	581.8	0.98	32.42	6.9
92	584.9	14.81	32.72	104.6
93	595.8	5.72	33.75	54.8
94	601.7	1.79	34.30	17.1
95	604.8	0.60	34.59	5.8
96	609.5	1.62	35.03	15.5
97	619.6	3.21	35.98	30.8
98	626.3	1.19	36.62	11.4
99	630.8	3.05	37.04	29.3
100	632.7	0.54	37.22	5.2
101	645.6	2.03	38.43	19.4
102	652.0	0.74	39.04	7.1
103	655.2	0.76	39.34	7.3
104	657.7	1.33	39.57	12.7
105	662.8	0.81	40.05	7.8

TABLE B.5 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	673.6	0.59	41.07	5.6
107	681.4	3.09	41.80	29.6
108	704.5	0.66	43.98	6.3

RI/CONC REPORT

Sample file : 17575h531.001a

COMMENTS : HP 531 hr CS lul no spike
P2

Total concentration : 349.661 ppm

Total number of peaks interpreted : 108

Peaks rejected before starting retention
time : 86Peaks rejected after final retention
time : 2

Peaks below minimum area threshold : 0

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.6 2-Methylpyridine Degradation:
625°F, 21 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.1	3.20	15.00	25.9
2	400.4	10.63	15.30	86.1
3	401.2	74.72	15.38	605.2
4	404.1	0.72	15.65	5.8
5	407.3	5.73	15.95	46.4
6	408.1	3.14	16.03	25.4
7	409.9	0.79	16.20	6.4
8	412.7	0.94	16.46	7.6
9	413.7	1.72	16.55	13.9
10	416.3	2.09	16.80	17.0
11	420.1	9.81	17.15	79.5
12	422.5	2.34	17.38	18.9
13	425.2	1.59	17.63	12.9
14	426.4	0.91	17.75	7.4
15	427.1	0.70	17.81	5.7
16	429.6	2.09	18.04	16.9
17	430.2	0.93	18.10	7.5
18	432.2	0.67	18.29	5.5
19	434.0	2.59	18.46	21.0
20	434.8	2.72	18.53	22.0
21	437.9	2.15	18.83	17.4
22	439.5	1.96	18.98	15.8
23	441.6	2.19	19.17	17.8
24	446.1	2.24	19.59	18.1
25	450.9	2.29	20.04	18.5
26	459.9	1.84	20.89	14.9
27	461.1	0.90	21.00	7.2
28	461.7	2.46	21.06	19.9
29	463.3	1.31	21.20	10.6
30	470.1	1.34	21.85	10.9
31	472.2	3.08	22.04	24.9
32	478.4	2.03	22.63	16.4
33	482.3	1.29	22.99	10.4
34	509.7	2.14	25.57	17.3
35	537.5	0.91	28.17	7.3

TABLE B.6 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	541.0	1.61	28.50	13.0
37	545.8	2.12	28.95	17.2
38	548.1	1.53	29.17	7.4
39	549.4	1.50	29.29	7.3
40	551.6	5.56	29.50	27.1
41	554.3	6.37	29.75	31.1
42	559.8	1.66	30.27	8.1
43	561.7	2.04	30.45	9.9
44	562.4	4.40	30.51	21.5
45	564.9	2.21	30.74	10.8
46	566.8	1.32	30.93	6.4
47	569.9	4.69	31.21	22.9
48	596.2	0.75	33.68	6.1
49	600.4	5.92	34.08	48.0
50	666.9	2.89	40.32	23.4
51	672.5	0.74	40.84	6.0
52	705.9	0.89	43.98	7.2

RI/CONC REPORT

Sample file : 37625h021.001a

COMMENTS : HP 625F 21Hr 1ul no spk
spless

Total concentration : 202.598 ppm

Total number of peaks interpreted : 52

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.7 2-Methylpyridine Degradation:
625°F, 189 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	6.94	15.03	56.2
2	399.3	1.46	15.23	11.8
3	399.9	1.94	15.27	15.7
4	401.7	8.37	15.44	67.8
5	403.4	12.16	15.60	98.5
6	404.9	9.03	15.74	73.1
7	407.4	5.27	15.98	42.7
8	408.0	11.23	16.03	91.0
9	409.8	2.96	16.20	24.0
10	411.0	5.32	16.32	43.1
11	412.5	8.44	16.45	68.4
12	413.4	3.49	16.54	28.3
13	414.8	10.47	16.67	84.8
14	416.1	20.73	16.80	167.9
15	420.0	42.62	17.17	345.3
16	420.9	10.50	17.26	85.1
17	422.1	3.95	17.36	32.0
18	423.0	2.52	17.45	20.4
19	425.0	11.56	17.63	93.7
20	426.1	4.53	17.74	36.7
21	426.9	2.93	17.82	23.7
22	428.2	1.08	17.94	8.8
23	429.3	6.35	18.05	51.4
24	430.0	6.49	18.11	52.6
25	431.9	6.89	18.29	55.8
26	433.7	9.58	18.46	77.6
27	435.0	19.07	18.58	154.5
28	436.9	2.13	18.76	17.3
29	437.6	14.53	18.83	117.7
30	439.7	5.12	19.03	41.5
31	441.3	4.91	19.17	39.7
32	442.8	1.32	19.32	10.7
33	444.0	0.90	19.43	7.3
34	445.7	4.61	19.59	37.4
35	446.5	0.86	19.67	7.0

TABLE B.7 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	447.3	2.53	19.74	20.5
37	450.2	12.64	20.02	102.4
38	454.0	3.22	20.38	26.1
39	455.4	1.08	20.51	8.7
40	456.7	3.32	20.63	26.9
41	459.4	7.49	20.88	60.7
42	460.3	2.81	20.96	22.7
43	461.3	2.29	21.06	18.6
44	462.6	2.64	21.19	21.4
45	466.0	1.05	21.51	8.5
46	469.5	10.71	21.84	86.8
47	471.7	5.07	22.05	41.1
48	473.8	1.87	22.24	15.1
49	474.6	1.10	22.32	8.9
50	475.4	0.80	22.39	6.5
51	476.4	0.75	22.49	6.1
52	478.0	2.79	22.64	22.6
53	480.7	1.33	22.89	10.8
54	481.8	1.63	23.00	13.2
55	482.6	2.22	23.07	17.9
56	483.8	0.72	23.19	5.8
57	485.0	1.32	23.30	10.7
58	486.0	1.30	23.39	10.5
59	486.8	0.90	23.47	7.3
60	487.6	4.77	23.54	38.7
61	489.0	1.44	23.68	11.6
62	490.4	0.65	23.81	5.3
63	492.8	3.09	24.04	25.0
64	494.3	0.71	24.18	5.8
65	494.9	0.71	24.24	5.8
66	496.5	1.55	24.39	12.5
67	497.8	0.83	24.50	6.7
68	498.6	1.63	24.58	13.2
69	500.4	1.22	24.75	9.9
70	501.3	1.62	24.84	13.1

TABLE B.7 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	503.3	1.66	25.02	13.5
72	504.5	1.51	25.14	12.2
73	505.4	2.26	25.22	18.3
74	506.7	1.80	25.35	14.5
75	509.0	6.64	25.57	53.8
76	510.9	3.32	25.74	26.9
77	512.5	7.68	25.90	62.2
78	514.0	1.21	26.03	9.8
79	515.1	1.06	26.14	8.6
80	516.6	3.39	26.29	27.4
81	519.4	1.68	26.55	13.6
82	522.3	5.81	26.82	47.1
83	524.3	2.31	27.01	18.7
84	525.9	1.23	27.16	9.9
85	527.3	1.26	27.29	10.2
86	529.1	4.79	27.47	38.8
87	531.9	0.95	27.72	7.7
88	533.5	1.46	27.88	11.8
89	536.3	3.71	28.14	30.0
90	537.5	0.96	28.26	7.8
91	538.6	1.59	28.36	12.9
92	541.2	5.41	28.61	43.8
93	542.7	1.09	28.74	8.8
94	544.2	1.96	28.89	15.9
95	544.8	2.84	28.94	23.0
96	545.8	1.49	29.04	7.2
97	548.3	11.73	29.28	57.3
98	549.6	1.64	29.39	8.0
99	550.9	2.67	29.52	13.0
100	552.0	2.09	29.62	10.2
101	554.0	5.77	29.82	28.2
102	556.7	3.28	30.07	16.0
103	558.5	7.86	30.23	38.4
104	559.3	4.38	30.31	21.4
105	560.5	1.98	30.42	9.6

TABLE B.7 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	561.5	11.71	30.52	57.2
107	563.8	8.33	30.74	40.7
108	565.5	1.20	30.90	5.9
109	566.8	1.39	31.02	6.8
110	567.8	2.50	31.11	12.2
111	569.0	8.66	31.23	42.3
112	571.5	2.16	31.47	10.5
113	574.0	6.83	31.70	33.4
114	575.0	3.76	31.79	18.4
115	576.1	1.49	31.90	7.3
116	577.0	1.09	31.98	5.3
117	578.1	2.05	32.09	10.0
118	579.1	6.28	32.18	30.7
119	580.9	1.69	32.35	8.3
120	581.5	3.92	32.41	19.1
121	583.5	2.42	32.60	11.8
122	584.8	10.18	32.72	49.7
123	586.0	3.99	32.83	19.5
124	587.6	3.82	32.98	18.6
125	589.0	1.31	33.12	6.4
126	594.7	1.53	33.65	12.4
127	595.7	5.10	33.74	41.3
128	601.6	2.02	34.30	16.4
129	609.2	1.37	35.02	11.1
130	611.4	2.57	35.23	20.8
131	619.3	2.35	35.98	19.0
132	630.5	1.74	37.03	14.1
133	632.3	0.63	37.20	5.1
134	635.4	1.00	37.50	8.1
135	639.5	1.09	37.88	8.8
136	641.1	1.52	38.03	12.3
137	645.3	0.99	38.43	8.0
138	651.6	4.48	39.02	36.3
139	657.3	2.06	39.56	16.7
140	662.4	0.94	40.04	7.6

TABLE B.7 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
141	669.1	0.91	40.67	7.4
142	673.5	1.41	41.09	11.4
143	674.3	0.92	41.16	7.5
144	680.9	5.04	41.79	40.8
145	704.0	1.05	43.97	8.5

RI/CONC REPORT

Sample file : 38625h189.001a

COMMENTS : HP 625F 189Hr 1ul no spk
splss

Total concentration : 594.829 ppm

Total number of peaks interpreted : 145

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.8 2-Methylpyridine Degradation:
625°F, 359 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	6.23	15.04	50.5
2	399.2	0.80	15.23	6.5
3	400.0	1.13	15.29	9.2
4	401.4	1.65	15.42	13.4
5	402.0	2.42	15.48	19.6
6	404.3	8.40	15.69	68.1
7	406.2	2.19	15.87	17.7
8	407.9	11.99	16.04	97.1
9	408.6	3.87	16.10	31.3
10	409.7	3.46	16.20	28.0
11	411.2	3.78	16.34	30.6
12	412.4	14.47	16.46	117.2
13	413.2	4.75	16.54	38.5
14	416.0	27.66	16.79	224.1
15	416.9	7.71	16.89	62.5
16	418.5	2.08	17.03	16.8
17	419.8	36.09	17.16	292.3
18	420.8	12.12	17.26	98.2
19	422.0	5.12	17.37	41.5
20	424.8	7.21	17.63	58.4
21	425.9	4.41	17.73	35.7
22	426.9	2.11	17.82	17.1
23	428.1	0.86	17.94	7.0
24	429.3	2.13	18.06	17.3
25	430.0	4.06	18.12	32.9
26	430.7	10.06	18.18	81.5
27	431.9	2.95	18.30	23.9
28	433.6	10.60	18.46	85.9
29	435.0	22.91	18.59	185.6
30	436.8	2.70	18.76	21.9
31	437.6	15.40	18.83	124.8
32	439.7	4.52	19.03	36.6
33	440.8	2.26	19.14	18.3
34	441.2	2.39	19.18	19.4
35	442.7	2.87	19.32	23.2

TABLE B.8 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	445.7	5.63	19.60	45.6
37	447.2	3.36	19.74	27.2
38	450.1	14.57	20.02	118.0
39	454.0	3.55	20.39	28.8
40	455.3	0.78	20.51	6.3
41	456.0	0.92	20.57	7.4
42	456.5	3.47	20.62	28.1
43	459.5	2.15	20.90	17.4
44	460.2	4.25	20.97	34.4
45	462.6	1.31	21.20	10.6
46	464.4	1.82	21.37	14.7
47	465.2	1.24	21.44	10.0
48	466.1	1.08	21.52	8.7
49	469.5	12.63	21.84	102.3
50	471.6	4.06	22.05	32.9
51	473.8	1.49	22.25	12.0
52	474.6	0.98	22.33	8.0
53	475.3	0.68	22.39	5.5
54	476.4	1.89	22.49	15.3
55	478.1	2.08	22.65	16.9
56	481.8	1.06	23.01	8.6
57	482.5	4.29	23.07	34.7
58	484.8	1.52	23.29	12.3
59	485.9	1.38	23.39	11.2
60	487.5	7.08	23.55	57.4
61	488.9	1.81	23.68	14.6
62	490.4	0.96	23.81	7.8
63	492.7	4.15	24.04	33.6
64	494.2	0.62	24.18	5.0
65	495.0	0.69	24.26	5.6
66	495.5	0.74	24.30	6.0
67	496.5	1.32	24.39	10.7
68	497.8	0.76	24.52	6.1
69	498.5	1.89	24.58	15.3
70	500.1	1.79	24.73	14.5

TABLE B.8 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	501.3	1.60	24.84	12.9
72	503.2	1.09	25.02	8.8
73	504.6	0.94	25.16	7.6
74	505.3	1.57	25.22	12.7
75	506.8	3.81	25.36	30.8
76	508.4	0.84	25.52	6.8
77	509.0	2.33	25.58	18.9
78	510.9	3.39	25.75	27.5
79	511.8	4.21	25.83	34.1
80	512.5	6.56	25.90	53.2
81	514.0	0.87	26.05	7.1
82	514.9	0.62	26.13	5.0
83	516.6	3.10	26.29	25.1
84	519.4	1.18	26.55	9.5
85	522.2	6.01	26.82	48.7
86	524.3	2.92	27.02	23.6
87	525.9	1.16	27.17	9.4
88	527.3	0.94	27.30	7.6
89	529.1	6.87	27.47	55.6
90	531.9	2.06	27.73	16.7
91	533.6	1.63	27.89	13.2
92	535.8	2.33	28.10	18.9
93	536.2	5.39	28.14	43.6
94	538.6	2.87	28.37	23.2
95	541.3	7.51	28.62	60.8
96	542.7	2.27	28.75	18.4
97	544.1	3.21	28.89	26.0
98	544.8	4.24	28.95	34.4
99	548.3	24.19	29.28	118.2
00	553.3	2.67	29.76	13.1
101	554.0	3.19	29.82	15.6
102	555.0	1.32	29.91	6.4
103	556.8	6.25	30.08	30.5
104	558.5	14.49	30.24	70.8
105	559.3	4.92	30.32	24.0

TABLE B.8 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	560.6	1.58	30.44	7.7
107	561.5	19.77	30.53	96.6
108	563.9	8.50	30.75	41.5
109	565.0	1.35	30.86	6.6
110	566.8	1.41	31.03	6.9
111	567.9	3.22	31.13	15.7
112	569.1	14.52	31.25	71.0
113	574.0	11.75	31.71	57.4
114	575.1	4.81	31.80	23.5
115	576.2	1.33	31.91	6.5
116	579.1	10.26	32.19	50.1
117	581.7	4.00	32.43	19.5
118	583.5	2.08	32.60	10.1
119	584.8	13.33	32.73	65.2
120	586.1	5.26	32.84	25.7
121	587.6	3.77	32.99	18.4
122	589.0	2.19	33.12	10.7
123	590.0	2.43	33.21	11.8
124	590.9	1.96	33.30	9.6
125	592.4	2.19	33.44	10.7
126	594.7	2.01	33.66	16.3
127	595.7	9.88	33.75	80.0
128	599.4	0.79	34.10	6.4
129	601.7	2.95	34.32	23.9
130	609.3	2.31	35.03	18.7
131	611.6	1.64	35.26	13.2
132	612.2	1.91	35.31	15.5
133	614.4	0.82	35.52	6.7
134	619.4	4.77	35.99	38.6
135	624.7	0.64	36.49	5.2
136	625.7	1.73	36.59	14.0
137	630.6	3.76	37.04	30.4
138	632.4	1.31	37.22	10.6
139	633.7	0.78	37.34	6.3
140	638.8	1.03	37.82	8.3

TABLE B.8 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
141	640.1	0.76	37.94	6.2
142	645.4	1.43	38.44	11.6
143	646.4	0.77	38.53	6.2
144	651.6	2.25	39.03	18.2
145	657.4	5.06	39.58	41.0
146	659.4	1.34	39.77	10.9
147	661.3	0.97	39.94	7.8
148	662.4	1.25	40.05	10.1
149	669.3	1.51	40.69	12.2
150	673.2	0.83	41.06	6.7
151	674.5	1.00	41.18	8.1
152	675.3	0.62	41.26	5.0
153	679.4	0.95	41.65	7.7
154	681.0	6.21	41.80	50.3
155	704.1	1.33	43.98	10.7

RI/CONC REPORT

Sample file : 39625h359.001a

COMMENTS : HP 625F 359Hr 1ul no spk
splss

Total concentration : 669.037 ppm

Total number of peaks interpreted : 155

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.9 2-Methylpyridine Degradation:
625°F, 525 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	7.20	15.03	58.3
2	399.1	1.34	15.22	10.9
3	401.8	2.72	15.45	22.0
4	403.4	4.26	15.60	34.5
5	404.4	1.50	15.70	12.1
6	405.1	3.11	15.76	25.2
7	406.2	2.78	15.87	22.5
8	407.9	15.37	16.03	124.5
9	409.6	6.74	16.18	54.6
10	411.3	3.40	16.35	27.6
11	412.5	20.74	16.46	168.0
12	414.9	9.22	16.68	74.7
13	416.0	34.59	16.79	280.2
14	419.8	38.92	17.15	315.3
15	420.9	10.60	17.25	85.9
16	421.9	3.76	17.35	30.5
17	424.8	5.76	17.62	46.6
18	426.0	1.69	17.73	13.7
19	426.8	0.84	17.81	6.8
20	427.5	1.83	17.88	14.8
21	429.9	11.04	18.10	89.4
22	431.8	11.02	18.28	89.3
23	433.9	5.68	18.48	46.0
24	435.1	30.15	18.59	244.2
25	436.8	2.77	18.75	22.4
26	437.6	15.97	18.83	129.3
27	439.7	4.46	19.02	36.1
28	440.8	2.35	19.13	19.0
29	442.7	3.53	19.31	28.6
30	445.9	1.80	19.61	14.6
31	447.2	4.92	19.74	39.9
32	450.1	14.11	20.01	114.3
33	454.1	4.70	20.38	38.1
34	456.0	0.95	20.57	7.7
35	456.7	3.48	20.63	28.2

TABLE B.9 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	459.6	1.34	20.91	10.9
37	460.2	4.78	20.96	38.7
38	462.8	3.57	21.20	28.9
39	465.8	3.57	21.49	28.9
40	467.9	0.75	21.69	6.1
41	469.5	14.39	21.84	116.6
42	471.7	4.49	22.05	36.4
43	473.8	1.64	22.25	13.3
44	474.6	1.14	22.33	9.3
45	475.4	1.14	22.40	9.2
46	476.5	0.88	22.50	7.1
47	478.1	1.68	22.66	13.6
48	478.7	1.48	22.71	12.0
49	479.9	0.89	22.82	7.2
50	481.7	2.69	23.00	21.8
51	482.6	2.48	23.08	20.1
52	483.8	2.20	23.19	17.8
53	484.9	2.64	23.30	21.4
54	486.0	1.98	23.40	16.0
55	486.8	0.96	23.47	7.8
56	487.5	8.13	23.54	65.8
57	489.0	2.59	23.68	21.0
58	490.4	1.45	23.81	11.7
59	492.7	4.66	24.04	37.7
60	494.3	1.31	24.19	10.6
61	495.0	0.77	24.25	6.2
62	495.5	1.09	24.30	8.8
63	496.5	2.00	24.40	16.2
64	497.9	1.31	24.52	10.6
65	498.5	2.23	24.58	18.1
66	500.1	2.51	24.73	20.3
67	501.2	2.48	24.84	20.1
68	503.1	3.17	25.01	25.7
69	504.8	2.43	25.17	19.7
70	505.2	1.95	25.21	15.8

TABLE B.9 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	506.8	4.29	25.36	34.8
72	508.5	1.30	25.52	10.5
73	509.0	2.58	25.57	20.9
74	511.0	5.12	25.76	41.5
75	511.8	5.55	25.83	45.0
76	512.6	9.50	25.91	77.0
77	515.1	1.81	26.14	14.6
78	516.6	5.49	26.29	44.4
79	517.9	0.92	26.42	7.5
80	519.4	3.85	26.55	31.2
81	520.5	1.16	26.66	9.4
82	522.3	7.49	26.83	60.7
83	524.4	3.57	27.03	28.9
84	525.9	1.82	27.17	14.8
85	527.4	0.77	27.31	6.2
86	528.9	8.11	27.45	65.7
87	531.9	2.26	27.73	18.3
88	533.6	1.52	27.90	12.3
89	534.8	0.99	28.01	8.0
90	535.7	11.19	28.10	90.6
91	538.7	3.75	28.37	30.4
92	541.3	13.24	28.62	107.2
93	544.2	3.28	28.90	26.6
94	544.8	5.81	28.95	47.1
95	548.2	29.71	29.28	145.2
96	552.1	2.34	29.64	11.4
97	552.5	2.48	29.68	12.1
98	554.2	1.89	29.84	9.2
99	554.8	4.55	29.90	22.2
100	556.9	5.44	30.10	26.6
101	558.5	22.11	30.25	108.1
102	559.3	9.19	30.33	44.4
103	560.6	2.03	30.44	9.9
104	561.5	22.64	30.53	110.7
105	563.9	10.92	30.75	53.4

TABLE B.9 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	565.1	4.46	30.87	21.8
107	566.7	2.49	31.03	12.1
108	567.9	6.06	31.13	29.6
109	569.2	28.32	31.25	138.4
110	572.7	1.11	31.58	5.4
111	574.1	25.81	31.72	126.2
112	575.1	10.92	31.81	53.4
113	576.2	3.23	31.92	15.8
114	578.2	3.73	32.11	18.2
115	579.1	10.16	32.20	49.7
116	580.9	3.73	32.36	18.2
117	581.6	6.60	32.43	32.2
118	583.5	2.75	32.61	13.4
119	584.8	23.04	32.73	112.6
120	586.1	8.73	32.85	42.6
121	587.2	2.94	32.95	14.3
122	587.9	2.22	33.02	10.8
123	588.9	5.59	33.12	27.3
124	589.9	2.85	33.21	13.9
125	591.3	4.00	33.34	19.5
126	592.5	4.43	33.46	21.6
127	594.6	3.38	33.66	27.4
128	595.6	17.12	33.75	138.7
129	599.3	1.12	34.10	9.1
130	601.7	2.82	34.33	22.8
131	601.9	2.76	34.35	22.4
132	603.9	0.79	34.53	6.4
133	604.8	1.24	34.62	10.0
134	606.3	0.94	34.76	7.6
135	607.3	0.81	34.85	6.5
136	609.3	3.80	35.04	30.7
137	611.6	2.53	35.26	20.5
138	612.3	3.45	35.33	27.9
139	614.2	1.30	35.50	10.5
140	616.2	0.93	35.70	7.5

TABLE B.9 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
141	619.4	10.33	35.99	83.7
142	620.9	0.81	36.14	6.6
143	625.7	1.91	36.59	15.5
144	630.5	5.75	37.04	46.6
145	632.4	1.30	37.23	10.5
146	637.3	1.53	37.68	12.4
147	638.7	1.49	37.82	12.1
148	640.1	0.94	37.95	7.6
149	641.4	1.06	38.07	8.6
150	645.3	2.78	38.44	22.5
151	646.8	0.98	38.59	7.9
152	649.1	0.68	38.80	5.5
153	650.4	1.01	38.92	8.1
154	651.5	1.96	39.03	15.9
155	653.4	1.21	39.21	9.8
156	655.0	1.63	39.36	13.2
157	657.3	9.25	39.58	74.9
158	659.3	2.48	39.77	20.1
159	661.2	1.84	39.94	14.9
160	662.3	2.01	40.05	16.3
161	669.2	1.78	40.70	14.4
162	673.0	2.18	41.06	17.7
163	674.3	1.85	41.18	15.0
164	679.4	1.37	41.66	11.1
165	680.9	5.91	41.80	47.9

TABLE B.9 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
166	690.8	1.59	42.74	12.9
167	692.7	1.65	42.92	13.4
168	704.0	1.28	43.99	10.4
169	707.2	0.82	44.29	6.6

RI/CONC REPORT

Sample file : 40625h525.001a

COMMENTS : HP 625F 525Hr 1ul no spk
splss

Total concentration : 881.157 ppm

Total number of peaks interpreted : 169

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.10 2-Methylpyridine Degradation:
625°F, 694 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	10.29	15.05	83.4
2	399.1	3.35	15.23	27.1
3	401.3	1.62	15.42	13.1
4	402.1	1.90	15.49	15.4
5	403.6	4.61	15.64	37.3
6	405.8	1.02	15.85	8.3
7	406.3	2.58	15.89	20.9
8	407.8	20.43	16.04	165.5
9	409.7	7.34	16.21	59.5
10	412.3	16.36	16.46	132.5
11	413.1	4.38	16.53	35.5
12	415.9	24.95	16.79	202.1
13	417.0	6.05	16.90	49.0
14	418.2	2.93	17.02	23.7
15	419.6	49.53	17.15	401.2
16	420.9	16.34	17.27	132.4
17	422.0	4.80	17.37	38.9
18	424.7	8.69	17.63	70.4
19	425.8	3.07	17.73	24.9
20	426.9	2.60	17.83	21.0
21	429.2	0.94	18.05	7.6
22	430.0	7.84	18.13	63.5
23	431.9	4.19	18.30	33.9
24	433.5	6.14	18.46	49.7
25	435.0	36.37	18.60	294.6
26	436.6	3.09	18.75	25.0
27	437.4	21.14	18.83	171.3
28	439.1	2.78	18.99	22.5
29	439.6	4.55	19.04	36.9
30	440.7	4.08	19.13	33.0
31	442.8	5.80	19.33	47.0
32	445.8	4.33	19.62	35.0
33	447.1	4.67	19.74	37.8
34	450.0	19.79	20.01	160.3
35	453.9	6.17	20.38	50.0

TABLE B.10 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	455.8	1.54	20.57	12.4
37	456.6	4.53	20.64	36.7
38	460.0	7.85	20.96	63.6
39	462.6	2.56	21.20	20.8
40	464.0	2.09	21.33	16.9
41	465.4	1.12	21.46	9.0
42	466.0	1.37	21.52	11.1
43	467.8	0.84	21.69	6.8
44	468.7	2.61	21.78	21.1
45	469.4	15.71	21.84	127.2
46	471.6	6.21	22.05	50.3
47	473.7	2.52	22.25	20.4
48	474.6	1.65	22.34	13.3
49	475.3	2.54	22.41	20.6
50	476.5	1.08	22.51	8.8
51	478.0	2.70	22.66	21.8
52	479.8	1.44	22.82	11.7
53	480.6	1.00	22.90	8.1
54	481.8	1.78	23.02	14.4
55	482.4	3.73	23.07	30.2
56	483.6	1.81	23.19	14.6
57	484.8	2.44	23.30	19.8
58	485.8	2.83	23.40	22.9
59	487.4	11.62	23.54	94.1
60	488.9	3.44	23.69	27.9
61	490.3	1.81	23.82	14.6
62	492.6	5.52	24.04	44.7
63	494.2	1.42	24.19	11.5
64	495.4	2.65	24.30	21.5
65	496.5	2.40	24.40	19.5
66	497.8	1.49	24.52	12.0
67	498.4	3.32	24.58	26.9
68	500.0	3.20	24.73	25.9
69	501.1	3.27	24.83	26.5
70	503.1	2.12	25.02	17.2

TABLE B.10 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	504.7	4.25	25.17	34.4
72	506.8	5.06	25.37	41.0
73	508.4	1.65	25.52	13.3
74	509.4	0.91	25.62	7.4
75	510.9	5.21	25.76	42.2
76	511.6	6.38	25.83	51.7
77	512.5	9.93	25.91	80.4
78	514.0	1.41	26.06	11.4
79	514.8	1.52	26.13	12.3
80	516.5	7.66	26.29	62.1
81	519.3	4.64	26.55	37.6
82	520.4	1.14	26.66	9.2
83	522.2	8.50	26.83	68.9
84	524.4	4.39	27.03	35.6
85	525.8	1.58	27.17	12.7
86	527.3	0.77	27.31	6.2
87	528.9	9.25	27.46	74.9
88	531.8	1.19	27.73	9.7
89	533.5	1.08	27.89	8.8
90	535.7	12.59	28.10	102.0
91	537.5	1.06	28.27	8.6
92	538.6	3.11	28.37	25.2
93	541.3	11.64	28.63	94.3
94	542.6	1.40	28.76	11.3
95	544.2	2.39	28.90	19.4
96	544.7	5.21	28.95	42.2
97	548.2	26.94	29.28	131.7
98	550.4	2.20	29.49	10.7
99	552.6	1.59	29.70	7.7
100	555.0	2.08	29.92	10.1
101	556.8	2.04	30.09	9.9
102	558.4	24.67	30.24	120.6
103	559.3	6.58	30.33	32.1
104	561.5	27.14	30.53	132.6
105	563.8	10.15	30.76	49.6

TABLE B.10 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	565.0	3.02	30.86	14.8
107	566.7	1.55	31.03	7.5
108	567.8	4.75	31.13	23.2
109	569.1	33.66	31.25	164.5
110	574.1	36.29	31.72	177.4
111	575.1	11.44	31.82	55.9
112	576.2	3.55	31.92	17.3
113	578.2	1.45	32.11	7.0
114	579.1	9.69	32.20	47.4
115	580.8	1.89	32.35	9.2
116	581.7	5.29	32.44	25.8
117	583.4	1.71	32.60	8.4
118	584.8	25.74	32.73	125.8
119	586.0	8.95	32.85	43.7
120	587.1	2.82	32.95	13.8
121	587.8	1.30	33.02	6.3
122	588.9	4.56	33.12	22.2
123	589.8	2.85	33.21	13.9
124	591.2	2.28	33.34	11.1
125	592.5	2.67	33.46	13.0
126	594.6	2.80	33.66	22.7
127	595.6	19.52	33.75	158.1
128	599.3	0.71	34.10	5.8
129	601.8	4.88	34.34	39.5
130	603.9	0.75	34.54	6.1
131	606.4	0.83	34.77	6.7
132	609.2	3.13	35.04	25.3
133	611.6	1.82	35.26	14.8
134	612.3	3.54	35.33	28.7
135	614.2	0.71	35.51	5.7
136	616.3	1.13	35.70	9.1
137	619.4	8.79	35.99	71.2
138	620.9	1.03	36.14	8.4
139	624.6	0.72	36.49	5.8
140	625.7	2.47	36.59	20.0

TABLE B.10 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
141	630.6	5.01	37.05	40.5
142	632.5	1.66	37.23	13.4
143	633.7	0.63	37.35	5.1
144	637.3	1.72	37.68	13.9
145	638.7	1.45	37.82	11.7
146	640.0	0.71	37.94	5.7
147	645.3	1.54	38.44	12.5
148	651.8	0.87	39.05	7.0
149	653.5	0.67	39.21	5.4
150	655.1	0.67	39.36	5.4
151	657.3	8.42	39.57	68.2
152	659.3	2.18	39.76	17.6
153	661.2	1.67	39.94	13.6
154	662.3	1.58	40.05	12.8
155	669.2	0.93	40.69	7.5
156	673.1	1.45	41.06	11.7
157	674.3	1.08	41.18	8.8
158	681.1	2.69	41.82	21.7
159	690.9	0.79	42.75	6.4
160	692.9	0.90	42.94	7.2
161	704.1	1.24	43.99	10.0

RI/CONC REPORT

Sample file : 41625h694.001a

COMMENTS : HP 625F 694Hr 1ul no spk
splss

Total concentration : 913.2 ppm

Total number of peaks interpreted : 161

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.11 2-Methylpyridine Degradation:
625°F, 837 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	13.65	15.02	98.1
2	399.1	6.00	15.21	43.2
3	400.5	1.86	15.32	13.3
4	401.3	4.16	15.40	29.9
5	402.1	3.94	15.47	28.3
6	403.6	3.93	15.61	28.2
7	404.3	2.53	15.68	18.1
8	405.3	1.98	15.78	14.3
9	406.3	3.54	15.87	25.4
10	407.9	30.37	16.02	218.4
11	409.7	5.60	16.19	40.2
12	412.4	31.23	16.44	224.5
13	413.2	7.16	16.52	51.4
14	414.5	1.15	16.64	8.3
15	416.0	26.10	16.78	187.7
16	417.1	7.46	16.89	53.6
17	418.4	3.94	17.01	28.3
18	419.7	63.45	17.14	456.2
19	421.0	20.21	17.26	145.3
20	422.1	5.49	17.36	39.4
21	424.8	9.54	17.62	68.6
22	425.9	5.82	17.72	41.8
23	427.1	4.94	17.83	35.5
24	430.0	11.51	18.11	82.8
25	432.0	5.44	18.29	39.1
26	433.4	5.15	18.43	37.0
27	435.1	46.38	18.59	333.5
28	436.7	3.89	18.74	28.0
29	437.6	27.19	18.82	195.5
30	439.2	4.94	18.97	35.5
31	439.8	4.87	19.03	35.0
32	440.8	5.73	19.13	41.2
33	442.9	9.06	19.32	65.1
34	445.9	5.53	19.61	39.8
35	447.2	6.11	19.74	43.9

TABLE B.11 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	450.1	25.53	20.00	183.5
37	454.0	7.71	20.37	55.4
38	456.0	2.01	20.56	14.4
39	456.7	3.51	20.63	25.2
40	460.2	12.30	20.96	88.5
41	462.7	4.14	21.20	29.7
42	464.1	2.28	21.33	16.4
43	465.4	1.54	21.46	11.1
44	466.1	1.86	21.51	13.4
45	467.9	1.50	21.68	10.8
46	468.8	3.37	21.77	24.2
47	469.5	19.59	21.84	140.8
48	471.6	8.13	22.04	58.4
49	473.8	3.09	22.24	22.2
50	474.7	2.15	22.33	15.5
51	475.4	3.63	22.40	26.1
52	476.6	1.92	22.51	13.8
53	478.1	5.53	22.65	39.7
54	479.9	1.87	22.82	13.4
55	480.7	0.86	22.90	6.2
56	481.9	1.57	23.01	11.3
57	482.5	4.02	23.07	28.9
58	483.7	1.62	23.18	11.7
59	484.9	3.18	23.29	22.9
60	485.9	3.82	23.39	27.5
61	487.5	14.46	23.54	104.0
62	489.0	4.87	23.68	35.0
63	490.4	2.45	23.81	17.6
64	492.7	6.18	24.03	44.4
65	494.4	1.73	24.19	12.4
66	495.6	4.21	24.30	30.2
67	496.6	4.12	24.40	29.6
68	497.9	2.42	24.52	17.4
69	498.5	4.04	24.58	29.1
70	500.0	4.56	24.72	32.8

TABLE B.11 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	501.2	4.49	24.83	32.3
72	503.2	2.62	25.02	18.9
73	504.7	5.42	25.17	39.0
74	506.9	6.38	25.37	45.8
75	508.5	1.68	25.52	12.1
76	509.5	1.22	25.62	8.7
77	511.0	6.35	25.76	45.6
78	511.7	9.13	25.83	65.7
79	512.6	12.39	25.91	89.1
80	514.0	1.59	26.05	11.4
81	514.8	1.99	26.12	14.3
82	516.5	8.97	26.28	64.5
83	519.3	5.83	26.55	41.9
84	520.5	1.55	26.65	11.1
85	522.3	9.89	26.83	71.1
86	524.4	5.22	27.03	37.5
87	525.9	2.11	27.17	15.2
88	526.7	0.80	27.24	5.7
89	527.4	0.93	27.30	6.7
90	528.9	12.45	27.44	89.5
91	531.8	1.98	27.73	14.2
92	533.6	2.20	27.89	15.8
93	535.7	18.07	28.09	129.9
94	537.5	2.03	28.26	14.6
95	538.6	6.12	28.36	44.0
96	541.3	16.27	28.62	117.0
97	542.7	1.93	28.75	13.8
98	544.9	9.80	28.96	70.4
99	548.3	44.26	29.28	196.9
100	550.4	9.29	29.48	41.3
101	552.6	3.68	29.68	16.3
102	553.3	2.39	29.75	10.6
103	554.0	1.71	29.82	7.6
104	555.0	3.35	29.91	14.9
105	556.9	5.74	30.09	25.5

TABLE B.11 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	558.5	37.24	30.24	165.7
107	559.4	12.42	30.33	55.2
108	560.5	2.63	30.44	11.7
109	561.5	25.41	30.53	113.0
110	563.9	14.51	30.76	64.6
111	565.1	7.34	30.87	32.6
112	566.8	3.86	31.03	17.1
113	567.8	6.55	31.12	29.1
114	569.2	48.71	31.25	216.7
115	571.8	1.62	31.51	7.2
116	572.9	3.23	31.60	14.3
117	574.1	59.74	31.72	265.8
118	575.2	16.80	31.82	74.8
119	576.2	6.87	31.91	30.6
120	578.2	3.26	32.11	14.5
121	579.2	11.75	32.20	52.3
122	580.8	1.98	32.35	8.8
123	581.7	8.33	32.43	37.0
124	583.6	5.16	32.62	22.9
125	584.8	38.20	32.73	170.0
126	586.0	13.20	32.85	58.7
127	587.1	4.88	32.95	21.7
128	587.8	2.22	33.02	9.8
129	588.9	7.34	33.12	32.6
130	589.9	5.54	33.21	24.6
131	591.3	4.17	33.34	18.5
132	592.4	5.41	33.45	24.1
133	594.6	4.33	33.66	31.1
134	595.6	32.11	33.75	230.9
135	599.3	6.33	34.10	45.5
136	601.9	8.01	34.35	57.6
137	603.9	1.39	34.54	10.0
138	604.8	1.98	34.62	14.3
139	606.4	2.32	34.77	16.7
140	607.4	1.55	34.86	11.1

TABLE B.11 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
141	609.2	5.45	35.04	39.2
142	611.6	3.58	35.26	25.7
143	612.3	4.71	35.32	33.9
144	614.1	1.54	35.49	11.1
145	616.3	2.04	35.70	14.6
146	619.3	16.71	35.99	120.1
147	620.9	1.41	36.14	10.1
148	624.6	0.91	36.49	6.6
149	625.6	3.47	36.58	24.9
150	629.0	0.85	36.90	6.1
151	630.5	6.99	37.04	50.3
152	632.4	2.20	37.22	15.8
153	635.4	0.77	37.51	5.5
154	637.2	2.66	37.68	19.1
155	638.7	1.98	37.82	14.2
156	640.1	1.00	37.95	7.2
157	645.3	1.69	38.44	12.2
158	649.1	0.75	38.80	5.4
159	653.3	0.90	39.20	6.4
160	655.0	1.61	39.36	11.6
161	657.3	11.37	39.58	81.7
162	659.3	2.92	39.76	21.0
163	661.3	2.28	39.96	16.4
164	662.3	2.25	40.05	16.2
165	667.4	0.91	40.53	6.5
166	669.0	3.04	40.69	21.9
167	673.1	2.76	41.06	19.8
168	674.3	1.80	41.18	12.9
169	681.0	1.99	41.81	14.3
170	687.4	0.76	42.42	5.5

TABLE B.11 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
171	704.0	1.63	43.99	11.7
172	707.4	0.87	44.31	6.3

RI/CONC REPORT

Sample file : 44625h837.001a

COMMENTS : HP 625F 837Hr 1ul no spk
splss

Total concentration : 1316.49 ppm

Total number of peaks interpreted : 172

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.12 2-Methylpyridine Degradation:
625°F, 1153 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	14.86	15.04	106.8
2	399.1	5.54	15.23	39.8
3	401.4	3.15	15.42	22.6
4	402.2	11.70	15.49	84.1
5	403.6	1.75	15.63	12.6
6	404.3	2.42	15.70	17.4
7	405.3	0.79	15.79	5.7
8	407.4	16.30	15.98	117.2
9	407.9	23.40	16.04	168.2
10	409.8	6.21	16.21	44.7
11	410.5	7.31	16.28	52.5
12	412.4	22.02	16.46	158.3
13	414.0	18.67	16.61	134.2
14	415.9	32.64	16.79	234.7
15	417.1	9.62	16.90	69.1
16	418.5	2.73	17.04	19.6
17	419.7	59.05	17.15	424.6
18	421.0	23.30	17.27	167.5
19	422.0	3.10	17.37	22.3
20	424.8	7.59	17.63	54.6
21	425.9	4.14	17.74	29.8
22	427.1	2.65	17.84	19.0
23	429.1	9.74	18.04	70.0
24	430.0	4.48	18.12	32.2
25	431.9	14.39	18.31	103.5
26	433.4	6.57	18.44	47.2
27	435.1	44.26	18.60	318.2
28	436.7	4.77	18.76	34.3
29	437.6	23.47	18.84	168.7
30	439.2	6.07	18.99	43.6
31	439.8	4.58	19.05	32.9
32	440.7	4.01	19.14	28.8
33	442.9	9.07	19.34	65.2
34	443.8	1.95	19.42	14.0
35	445.9	4.98	19.62	35.8

TABLE B.12 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	447.2	5.76	19.75	41.4
37	450.1	20.25	20.02	145.6
38	454.1	6.07	20.40	43.6
39	455.9	3.06	20.57	22.0
40	460.1	8.82	20.96	63.4
41	462.7	5.31	21.21	38.2
42	464.0	3.11	21.34	22.3
43	465.4	1.73	21.46	12.4
44	466.1	1.10	21.53	7.9
45	467.8	2.09	21.70	15.0
46	468.7	4.00	21.78	28.7
47	469.5	17.30	21.85	124.4
48	471.6	7.94	22.05	57.1
49	473.7	2.62	22.25	18.8
50	474.7	2.23	22.34	16.0
51	475.4	4.23	22.41	30.4
52	478.1	2.47	22.66	17.7
53	478.8	1.93	22.73	13.8
54	479.9	2.25	22.83	16.2
55	480.7	1.58	22.91	11.3
56	481.9	1.39	23.02	10.0
57	482.4	5.19	23.08	37.3
58	484.9	2.61	23.30	18.8
59	485.9	4.70	23.40	33.8
60	487.4	13.15	23.55	94.6
61	488.9	5.14	23.69	36.9
62	490.4	1.97	23.82	14.2
63	492.7	6.64	24.04	47.7
64	494.3	1.61	24.20	11.5
65	495.5	4.33	24.31	31.1
66	496.5	3.91	24.40	28.1
67	497.8	2.06	24.53	14.8
68	498.4	3.04	24.58	21.8
69	499.9	4.52	24.73	32.5
70	501.2	1.18	24.85	8.5

TABLE B.12 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	501.7	2.42	24.89	17.4
72	503.1	2.97	25.03	21.3
73	504.7	9.20	25.17	66.2
74	506.8	9.05	25.38	65.0
75	508.4	0.91	25.52	6.5
76	509.5	1.45	25.63	10.4
77	510.9	6.05	25.77	43.5
78	511.6	8.71	25.83	62.6
79	512.5	13.33	25.91	95.9
80	514.2	1.47	26.08	10.6
81	514.8	2.37	26.13	17.0
82	516.5	8.65	26.29	62.2
83	519.3	9.25	26.56	66.5
84	520.4	2.49	26.66	17.9
85	522.2	10.42	26.83	74.9
86	524.3	5.81	27.03	41.8
87	525.8	1.58	27.17	11.4
88	526.6	0.74	27.25	5.3
89	527.4	0.80	27.32	5.7
90	528.7	13.37	27.45	96.2
91	531.8	3.42	27.74	24.6
92	533.5	3.06	27.90	22.0
93	534.4	0.83	27.98	6.0
94	535.6	25.95	28.10	186.6
95	538.5	6.72	28.37	48.3
96	541.2	22.88	28.63	164.5
97	544.8	11.24	28.96	80.8
98	548.2	46.20	29.28	205.6
99	551.1	11.04	29.56	49.1
100	552.5	5.84	29.70	26.0
101	553.4	3.85	29.77	17.1
102	554.1	3.11	29.84	13.8
103	554.9	4.20	29.92	18.6
104	557.0	9.41	30.12	41.8
105	558.4	58.73	30.25	261.3

TABLE B.12 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	561.5	35.72	30.54	158.9
107	563.7	13.26	30.75	59.0
108	565.0	10.38	30.88	46.2
109	566.7	6.55	31.04	29.1
110	567.8	11.00	31.13	48.9
111	569.1	64.06	31.26	285.1
112	572.0	1.57	31.53	6.9
113	572.7	2.48	31.60	11.0
114	574.2	92.44	31.74	411.3
115	575.1	18.51	31.83	82.3
116	576.1	8.40	31.92	37.3
117	578.1	5.30	32.11	23.6
118	579.1	14.12	32.20	62.8
119	580.8	2.84	32.37	12.6
120	581.6	7.68	32.44	34.1
121	583.2	2.79	32.59	12.4
122	584.8	59.95	32.75	266.8
123	586.0	11.55	32.85	51.4
124	587.0	5.26	32.95	23.4
125	587.8	3.63	33.03	16.1
126	588.8	10.20	33.12	45.4
127	589.9	4.72	33.22	21.0
128	591.3	4.51	33.36	20.0
129	592.5	4.08	33.47	18.1
130	594.6	4.45	33.66	32.0
131	595.5	36.80	33.76	264.6
132	599.3	2.28	34.11	16.4
133	601.9	8.19	34.36	58.9
134	603.8	1.84	34.53	13.2
135	604.7	0.87	34.62	6.2
136	605.7	0.99	34.71	7.1
137	606.6	1.39	34.80	10.0
138	607.4	2.46	34.88	17.7
139	609.1	4.34	35.04	31.2
140	611.5	4.54	35.27	32.6

TABLE B.12 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
141	612.1	6.19	35.32	44.5
142	614.7	0.83	35.56	6.0
143	616.2	2.61	35.71	18.8
144	617.4	1.33	35.82	9.6
145	619.2	11.21	35.99	80.6
146	620.8	1.90	36.15	13.6
147	622.3	1.78	36.29	12.8
148	624.5	1.17	36.49	8.4
149	625.6	4.33	36.59	31.1
150	628.9	2.10	36.90	15.1
151	630.6	4.24	37.07	30.5
152	632.4	2.46	37.24	17.7
153	637.1	3.08	37.68	22.2
154	638.6	1.88	37.82	13.5
155	639.9	1.21	37.95	8.7
156	645.2	2.53	38.45	18.2
157	649.0	1.71	38.81	12.3
158	649.8	0.92	38.89	6.6
159	651.7	0.74	39.07	5.3
160	653.3	0.94	39.21	6.7
161	657.2	10.00	39.58	71.9
162	659.1	1.78	39.76	12.8
163	659.9	1.07	39.84	7.7
164	661.1	2.17	39.95	15.6
165	662.2	2.26	40.06	16.3
166	667.4	0.92	40.54	6.6
167	669.0	2.43	40.70	17.5
168	670.7	0.80	40.86	5.7
169	672.9	1.12	41.06	8.0
170	674.2	1.62	41.18	11.6

TABLE B.12 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
171	680.9	0.76	41.82	5.4
172	703.9	1.11	43.99	8.0

RI/CONC REPORT

Sample file : 456251153.001a

COMMENTS : HP 625F 1153Hr lul nospk
splss

Total concentration : 1459.27 ppm

Total number of peaks interpreted : 172

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.13 2-Methylpyridine Degradation:
675°F, Initial Material**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	399.9	5.27	15.28	37.8
2	400.2	1.87	15.30	13.4
3	400.8	45.76	15.37	329.0
4	407.0	5.04	15.95	36.2
5	419.9	2.11	17.16	15.1
6	423.7	0.87	17.52	6.3
7	424.8	0.95	17.63	6.8
8	429.3	1.94	18.05	13.9
9	442.5	0.77	19.30	5.5
10	471.3	1.87	22.02	13.4
11	484.4	5.66	23.25	40.7
12	609.8	0.75	35.09	5.4
13	610.8	0.99	35.18	7.1
14	665.8	1.05	40.36	7.5
15	704.2	0.70	43.99	5.0

RI/CONC REPORT

Sample file : 46675h000.001a

COMMENTS : HP 675F 0Hr 1ul no spk spless

Total concentration : 75.6642 ppm

Total number of peaks interpreted : 15

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.14 2-Methylpyridine Degradation:
675°F, 22 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	1.91	15.04	13.7
2	398.7	1.23	15.20	8.8
3	404.2	2.96	15.69	21.3
4	405.6	1.75	15.82	12.6
5	407.0	4.21	15.96	30.3
6	407.8	8.40	16.03	60.4
7	410.3	7.89	16.27	56.7
8	412.4	1.11	16.47	7.9
9	413.4	1.89	16.55	13.6
10	414.7	1.61	16.68	11.6
11	415.9	8.91	16.79	64.1
12	417.1	4.02	16.91	28.9
13	418.3	4.99	17.02	35.8
14	419.7	41.67	17.15	299.6
15	420.6	14.19	17.24	102.0
16	423.7	1.62	17.53	11.7
17	424.7	7.78	17.63	56.0
18	426.0	1.23	17.74	8.8
19	426.8	4.88	17.82	35.1
20	429.3	13.06	18.06	93.9
21	432.0	0.73	18.32	5.2
22	433.7	1.09	18.48	7.9
23	435.1	1.93	18.60	13.9
24	437.5	8.11	18.84	58.3
25	439.8	5.83	19.05	41.9
26	441.2	1.75	19.18	12.5
27	447.8	5.56	19.80	40.0
28	449.3	2.50	19.95	17.9
29	450.4	2.47	20.05	17.7
30	451.1	5.01	20.12	36.0
31	454.9	6.71	20.48	48.3
32	457.2	2.02	20.69	14.5
33	459.1	1.29	20.87	9.3
34	460.1	0.82	20.97	5.9
35	461.4	2.17	21.08	15.6

TABLE B.14 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	469.7	2.59	21.87	18.6
37	472.1	0.73	22.10	5.2
38	474.5	1.01	22.32	7.2
39	479.2	1.07	22.77	7.7
40	482.5	0.84	23.08	6.0
41	488.1	0.73	23.61	5.2
42	490.3	0.75	23.82	5.4
43	492.6	1.85	24.03	13.3
44	493.5	4.48	24.12	32.2
45	495.6	0.88	24.31	6.3
46	497.8	1.07	24.52	7.6
47	498.7	1.56	24.61	11.2
48	501.2	1.61	24.84	11.6
49	508.4	0.84	25.52	6.0
50	509.2	0.89	25.59	6.4
51	510.7	1.70	25.74	12.2
52	512.7	3.56	25.93	25.6
53	513.9	1.62	26.04	11.7
54	522.3	2.06	26.83	14.8
55	525.9	0.77	27.18	5.5
56	529.5	1.15	27.51	8.3
57	537.6	2.37	28.27	17.0
58	541.3	0.83	28.63	6.0
59	545.0	1.34	28.97	9.6
60	547.0	1.57	29.17	7.0
61	548.6	5.13	29.32	22.8
62	550.7	2.56	29.52	11.4
63	552.6	1.15	29.70	5.1
64	553.9	1.86	29.82	8.2
65	559.2	1.71	30.32	7.6
66	561.7	2.36	30.55	10.5
67	563.5	1.22	30.72	5.4
68	565.0	2.62	30.86	11.6
69	585.2	3.54	32.77	15.7
70	594.7	1.70	33.67	12.2

TABLE B.14 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	611.5	2.37	35.25	17.0
72	615.8	1.49	35.66	10.7
73	641.1	2.64	38.04	19.0
74	645.3	6.89	38.44	49.5
75	646.8	3.07	38.58	22.1
76	669.2	0.92	40.69	6.6
77	704.0	0.90	43.98	6.5

RI/CONC REPORT

Sample file : 47675h022.001a

COMMENTS : HP 675F 22Hr 1ul no spk spless

Total concentration : 263.69 ppm

Total number of peaks interpreted : 77

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.15 2-Methylpyridine Degradation:
675°F, 191 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	5.00	15.08	36.0
2	399.5	1.10	15.29	7.9
3	403.5	6.57	15.66	47.2
4	405.4	1.41	15.83	10.1
5	406.3	2.58	15.92	18.6
6	407.7	25.78	16.05	185.4
7	409.7	4.66	16.24	33.5
8	411.6	1.97	16.42	14.2
9	412.3	4.84	16.49	34.8
10	413.1	4.03	16.56	28.9
11	414.9	3.45	16.73	24.8
12	415.7	29.35	16.81	211.0
13	416.8	4.65	16.91	33.4
14	418.3	1.11	17.05	8.0
15	419.4	68.71	17.16	494.0
16	420.4	14.06	17.25	101.1
17	421.8	2.68	17.38	19.3
18	424.6	7.26	17.65	52.2
19	425.8	1.45	17.76	10.4
20	426.8	2.59	17.85	18.6
21	429.9	17.90	18.14	128.7
22	432.0	2.79	18.34	20.1
23	433.3	2.32	18.47	16.7
24	434.8	12.93	18.61	93.0
25	437.3	15.72	18.84	113.0
26	438.6	3.44	18.96	24.7
27	439.7	11.60	19.07	83.4
28	441.1	1.87	19.20	13.4
29	442.3	4.22	19.32	30.3
30	447.5	8.06	19.80	57.9
31	449.1	6.27	19.95	45.1
32	450.0	4.21	20.04	30.2
33	450.9	2.36	20.12	17.0
34	453.9	3.92	20.41	28.2
35	454.6	3.02	20.47	21.7

TABLE B.15 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	456.4	13.30	20.64	95.7
37	458.8	1.71	20.87	12.3
38	459.3	1.01	20.91	7.3
39	459.9	3.94	20.97	28.3
40	461.3	0.76	21.10	5.4
41	462.6	1.92	21.23	13.8
42	465.6	0.74	21.51	5.3
43	469.4	8.46	21.87	60.8
44	471.9	3.10	22.10	22.3
45	473.5	1.60	22.26	11.5
46	474.4	2.10	22.34	15.1
47	476.3	1.15	22.52	8.2
48	478.0	1.27	22.68	9.1
49	479.6	2.55	22.83	18.3
50	482.3	2.83	23.09	20.3
51	483.5	1.64	23.19	11.8
52	484.8	2.77	23.32	19.9
53	485.6	4.62	23.40	33.2
54	487.5	3.59	23.58	25.8
55	488.7	3.24	23.69	23.3
56	490.2	1.59	23.83	11.4
57	492.4	2.98	24.04	21.4
58	493.1	3.48	24.10	25.0
59	494.3	1.01	24.21	7.2
60	495.4	2.81	24.32	20.2
61	496.3	2.16	24.41	15.5
62	497.7	1.45	24.53	10.4
63	498.5	1.46	24.61	10.5
64	500.2	1.38	24.77	9.9
65	501.0	2.14	24.84	15.4
66	510.6	0.83	25.75	6.0
67	512.5	9.43	25.93	67.8
68	519.4	1.18	26.58	8.5
69	522.1	6.37	26.84	45.8
70	524.3	2.15	27.04	15.4

TABLE B.15 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	525.8	1.05	27.19	7.5
72	529.4	3.42	27.53	24.6
73	531.6	1.48	27.74	10.7
74	536.4	1.26	28.18	9.1
75	537.3	0.91	28.27	6.5
76	538.5	1.52	28.39	10.9
77	541.3	6.24	28.65	44.9
78	542.6	1.32	28.77	9.5
79	543.6	0.69	28.86	5.0
80	544.8	2.50	28.98	18.0
81	548.3	13.80	29.31	61.4
82	550.5	6.88	29.52	30.6
83	558.7	4.95	30.29	22.0
84	561.6	3.74	30.56	16.6
85	564.9	8.74	30.87	38.9
86	566.7	1.25	31.04	5.5
87	567.9	2.63	31.16	11.7
88	569.4	6.34	31.30	28.2
89	574.1	2.65	31.74	11.8
90	574.9	3.16	31.82	14.0
91	579.4	1.40	32.24	6.2
92	581.6	1.34	32.45	5.9
93	585.1	3.88	32.79	17.2
94	585.9	4.94	32.85	21.9
95	592.6	4.60	33.48	20.4
96	594.6	5.74	33.67	41.3
97	596.2	1.68	33.82	12.1
98	601.9	0.80	34.36	5.7
99	611.5	2.23	35.27	16.0
100	612.3	1.47	35.34	10.6
101	615.8	2.69	35.67	19.3
102	640.6	0.89	38.01	6.4
103	645.3	5.36	38.45	38.5
104	647.7	0.77	38.68	5.5
105	657.7	0.90	39.62	6.4

TABLE B.15 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	669.3	1.26	40.71	9.0
107	704.1	0.97	44.00	7.0

RI/CONC REPORT

Sample file : 48675h19l.001a

COMMENTS : HP 675F 19lHr 1ul no spk
splss

Total concentration : 512.596 ppm

Total number of peaks interpreted : 107

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.16 2-Methylpyridine Degradation:
675°F, 359 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	7.43	15.08	53.4
2	399.6	1.15	15.30	8.2
3	401.1	0.81	15.43	5.8
4	403.8	10.78	15.68	77.5
5	407.8	39.55	16.06	284.4
6	409.6	8.22	16.23	59.1
7	412.3	8.92	16.48	64.1
8	413.1	3.61	16.56	26.0
9	415.7	40.50	16.81	291.2
10	418.4	0.70	17.06	5.0
11	419.5	78.46	17.16	564.1
12	420.5	13.33	17.26	95.9
13	421.8	1.30	17.38	9.3
14	424.7	8.42	17.65	60.5
15	426.6	5.18	17.83	37.2
16	429.9	26.41	18.14	189.9
17	431.8	2.58	18.32	18.5
18	433.2	3.45	18.46	24.8
19	434.8	19.83	18.61	142.6
20	437.3	19.20	18.84	138.1
21	438.6	6.49	18.96	46.6
22	439.8	14.91	19.07	107.2
23	441.1	2.07	19.20	14.9
24	442.3	6.94	19.31	49.9
25	447.1	7.02	19.76	50.4
26	447.6	5.07	19.81	36.4
27	449.1	7.19	19.95	51.7
28	450.0	7.70	20.04	55.3
29	454.0	7.88	20.41	56.7
30	455.8	1.49	20.58	10.7
31	456.5	19.21	20.65	138.1
32	458.7	2.57	20.86	18.4
33	459.8	7.18	20.96	51.6
34	461.3	1.52	21.11	10.9
35	462.6	3.17	21.22	22.8

TABLE B.16 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	464.4	0.82	21.40	5.9
37	465.5	1.16	21.50	8.4
38	468.7	1.26	21.80	9.1
39	469.4	10.58	21.86	76.1
40	471.8	5.49	22.09	39.5
41	473.5	2.45	22.25	17.6
42	474.4	2.05	22.34	14.8
43	475.1	2.38	22.40	17.1
44	478.0	1.52	22.67	10.9
45	479.6	3.52	22.83	25.3
46	482.3	3.49	23.08	25.1
47	483.4	2.66	23.19	19.1
48	484.8	4.96	23.32	35.6
49	485.5	6.30	23.39	45.3
50	487.4	5.76	23.56	41.4
51	488.7	4.88	23.68	35.1
52	490.2	2.39	23.82	17.2
53	492.4	3.57	24.04	25.7
54	493.1	3.58	24.10	25.7
55	494.3	1.45	24.21	10.4
56	495.3	4.28	24.31	30.8
57	496.3	2.94	24.40	21.1
58	497.7	1.77	24.53	12.7
59	498.4	1.71	24.60	12.3
60	500.2	2.10	24.77	15.1
61	501.0	2.62	24.84	18.8
62	505.9	0.73	25.30	5.3
63	506.9	1.24	25.40	8.9
64	512.5	12.51	25.93	90.0
65	516.2	0.69	26.28	5.0
66	519.5	2.73	26.59	19.6
67	522.1	8.44	26.83	60.7
68	524.3	3.43	27.04	24.7
69	525.8	2.12	27.18	15.2
70	529.4	5.47	27.52	39.3

TABLE B.16 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	531.6	0.83	27.73	5.9
72	533.3	2.03	27.88	14.6
73	534.6	0.94	28.01	6.7
74	536.1	3.86	28.15	27.8
75	537.1	1.84	28.25	13.2
76	538.5	3.09	28.38	22.2
77	541.2	10.65	28.63	76.6
78	542.7	2.39	28.77	17.2
79	543.7	1.21	28.87	8.7
80	544.8	4.26	28.97	30.6
81	548.2	25.73	29.29	114.5
82	550.5	11.38	29.51	50.6
83	558.6	14.42	30.27	64.2
84	561.6	6.22	30.55	27.6
85	563.5	2.00	30.74	8.9
86	564.9	12.24	30.86	54.4
87	566.8	1.98	31.04	8.8
88	567.8	5.47	31.14	24.3
89	569.4	12.26	31.29	54.5
90	572.4	1.28	31.57	5.7
91	574.2	5.15	31.74	22.9
92	575.0	4.58	31.81	20.4
93	576.2	1.72	31.93	7.6
94	579.5	2.57	32.24	11.4
95	581.7	1.79	32.44	7.9
96	585.2	5.58	32.78	24.8
97	586.0	6.45	32.85	28.7
98	589.9	2.41	33.22	10.7
99	592.7	2.75	33.48	12.2
100	594.7	3.78	33.67	27.2
101	595.7	3.97	33.77	28.5
102	602.0	1.92	34.36	13.8
103	611.6	2.07	35.26	14.9
104	612.4	2.92	35.34	21.0
105	613.9	0.70	35.49	5.0

TABLE B.16 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	615.9	4.37	35.67	31.4
107	619.6	1.47	36.02	10.5
108	625.2	0.85	36.55	6.1
109	632.4	0.93	37.22	6.7
110	640.7	1.33	38.01	9.6
111	645.3	6.32	38.45	45.4
112	646.9	0.82	38.59	5.9
113	648.2	0.77	38.71	5.5
114	657.8	1.24	39.62	8.9
115	662.6	0.73	40.07	5.3
116	669.3	1.56	40.71	11.2
117	691.0	1.23	42.75	8.8
118	704.2	1.56	43.99	11.2

RI/CONC REPORT

Sample file : 49675h359.001a

COMMENTS : HP 675F 359Hr lul no spk
splss

Total concentration : 719.522 ppm

Total number of peaks interpreted : 118

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.17 2-Methylpyridine Degradation:
675°F, 514 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	391.0	2.88	15.05	20.7
2	396.5	7.36	15.43	52.9
3	400.8	7.07	15.76	50.8
4	402.6	2.00	15.93	14.4
5	403.6	3.02	16.02	21.7
6	404.3	1.73	16.09	12.4
7	405.0	1.83	16.15	13.2
8	407.9	24.04	16.42	172.8
9	408.0	3.55	16.44	25.5
10	408.1	1.69	16.45	12.1
11	408.2	9.43	16.46	67.8
12	409.7	7.78	16.60	56.0
13	412.3	19.54	16.84	140.5
14	413.2	6.83	16.92	49.1
15	415.9	32.98	17.18	237.1
16	419.7	3.07	17.54	22.1
17	419.8	5.94	17.55	42.7
18	420.6	2.56	17.62	18.4
19	422.0	2.57	17.76	18.5
20	424.8	5.39	18.02	38.8
21	427.0	4.08	18.23	29.3
22	430.0	29.52	18.51	212.3
23	431.8	3.91	18.68	28.1
24	433.4	2.11	18.83	15.2
25	435.0	18.81	18.98	135.2
26	436.7	1.39	19.14	10.0
27	437.5	17.04	19.22	122.5
28	438.8	8.63	19.34	62.1
29	439.9	15.77	19.45	113.4
30	441.3	2.54	19.58	18.3
31	442.5	8.16	19.69	58.7
32	445.1	0.77	19.94	5.5
33	446.3	0.71	20.04	5.1
34	447.2	12.48	20.13	89.7
35	449.2	6.92	20.32	49.8

TABLE B.17 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	450.1	8.68	20.41	62.4
37	454.1	7.23	20.78	52.0
38	455.3	0.92	20.90	6.6
39	456.6	19.34	21.02	139.0
40	460.0	10.80	21.34	77.7
41	461.5	1.04	21.48	7.5
42	462.7	4.23	21.60	30.4
43	464.7	0.70	21.78	5.0
44	465.5	1.37	21.86	9.8
45	468.8	1.08	22.17	7.8
46	469.5	9.93	22.23	71.4
47	471.9	5.01	22.46	36.0
48	473.7	2.54	22.63	18.2
49	474.6	1.86	22.71	13.3
50	475.3	2.18	22.78	15.6
51	476.5	1.53	22.89	11.0
52	478.1	2.51	23.04	18.1
53	479.7	3.14	23.20	22.5
54	482.5	2.76	23.46	19.8
55	483.5	2.49	23.55	17.9
56	484.9	6.55	23.69	47.1
57	485.7	6.14	23.76	44.2
58	487.6	5.94	23.94	42.7
59	488.8	5.07	24.06	36.4
60	490.3	2.55	24.20	18.3
61	492.6	5.35	24.41	38.4
62	494.3	1.64	24.58	11.8
63	495.5	4.16	24.68	29.9
64	496.5	3.05	24.78	21.9
65	497.8	1.66	24.90	11.9
66	498.6	1.63	24.98	11.7
67	500.3	2.41	25.14	17.3
68	501.0	2.19	25.21	15.7
69	503.1	0.96	25.40	6.9
70	504.7	0.70	25.55	5.0

TABLE B.17 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	507.0	1.26	25.77	9.0
72	512.6	16.13	26.30	115.9
73	516.5	1.91	26.67	13.7
74	519.4	4.89	26.94	35.2
75	522.2	8.05	27.21	57.8
76	524.4	2.21	27.41	15.9
77	525.9	1.06	27.55	7.6
78	529.4	5.25	27.88	37.7
79	535.9	5.56	28.49	40.0
80	537.5	1.22	28.64	8.7
81	538.6	5.25	28.75	37.7
82	541.2	20.94	29.00	93.1
83	542.6	3.05	29.13	13.6
84	543.9	1.19	29.25	5.3
85	544.9	6.57	29.34	29.2
86	548.3	32.16	29.66	143.1
87	550.6	13.30	29.88	59.2
88	558.5	18.73	30.63	83.3
89	561.6	6.79	30.92	30.2
90	563.7	3.42	31.12	15.2
91	564.9	12.64	31.23	56.2
92	566.8	1.90	31.41	8.4
93	567.9	7.06	31.51	31.4
94	569.4	12.24	31.66	54.4
95	572.4	1.54	31.94	6.8
96	574.2	17.15	32.10	76.3
97	576.1	1.43	32.29	6.3
98	581.7	2.51	32.81	11.2
99	585.2	9.30	33.14	41.4
00	586.0	6.54	33.22	29.1
101	587.0	1.23	33.31	5.4
102	589.1	1.26	33.51	5.6
103	590.0	2.00	33.59	8.9
104	592.5	4.31	33.83	31.0
105	594.7	5.12	34.04	36.8

TABLE B.17 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	595.7	6.55	34.13	47.1
107	600.1	1.18	34.55	8.5
108	601.9	3.25	34.72	23.3
109	603.8	0.88	34.90	6.3
110	611.6	1.30	35.63	9.3
111	611.7	0.71	35.64	5.1
112	612.4	2.72	35.71	19.6
113	615.9	2.92	36.04	21.0
114	619.5	2.31	36.38	16.6
115	622.8	0.76	36.69	5.5
116	625.2	0.80	36.92	5.7
117	632.5	0.86	37.60	6.1
118	640.7	1.30	38.38	9.3
119	645.4	5.93	38.82	42.7
120	646.7	0.70	38.94	5.0
121	657.6	1.83	39.97	13.1
122	661.6	1.25	40.34	9.0
123	662.5	1.15	40.44	8.3
124	664.5	0.80	40.62	5.7
125	669.3	0.99	41.07	7.1
126	679.0	0.77	41.98	5.5
127	690.8	1.66	43.10	11.9
128	693.0	4.02	43.31	28.9
129	693.9	9.85	43.39	70.8
130	700.5	0.79	44.01	5.6
131	704.2	1.09	44.36	7.9

RI/CONC REPORT

Sample file : 50675h514.001a

COMMENTS : HP 675F 514Hr 1ul no spk
splss

Total concentration : 725.635 ppm

Total number of peaks interpreted : 131

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.18 2-Methylpyridine Degradation:
675°F, 532 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	9.03	15.07	64.9
2	399.7	1.25	15.29	9.0
3	401.2	2.55	15.43	18.3
4	402.0	2.22	15.51	15.9
5	403.6	3.97	15.66	28.5
6	404.4	3.78	15.73	27.2
7	405.5	8.28	15.83	59.5
8	407.8	43.33	16.05	311.5
9	409.7	13.42	16.23	96.5
10	412.4	7.40	16.48	53.2
11	413.3	11.98	16.57	86.1
12	415.8	32.18	16.81	231.4
13	417.0	14.26	16.91	102.5
14	418.3	2.18	17.04	15.7
15	419.5	77.95	17.16	560.5
16	420.6	12.82	17.26	92.2
17	421.9	3.74	17.38	26.9
18	424.8	6.53	17.65	47.0
19	426.0	0.76	17.77	5.5
20	427.1	4.01	17.87	28.9
21	428.3	1.14	17.99	8.2
22	429.9	25.95	18.14	186.6
23	431.9	4.96	18.32	35.7
24	433.3	2.20	18.45	15.8
25	434.9	23.07	18.61	165.9
26	437.4	20.35	18.84	146.3
27	438.6	7.88	18.96	56.6
28	439.8	16.65	19.07	119.7
29	441.2	1.76	19.20	12.6
30	442.4	7.54	19.31	54.2
31	444.6	0.85	19.52	6.1
32	447.1	13.65	19.76	98.1
33	449.2	5.74	19.95	41.2
34	450.0	8.47	20.03	60.9
35	454.0	7.22	20.41	51.9

TABLE B.18 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	455.8	3.66	20.57	26.3
37	456.5	19.55	20.64	140.5
38	458.9	2.74	20.86	19.7
39	459.9	7.69	20.96	55.3
40	461.4	0.87	21.11	6.3
41	462.6	4.34	21.22	31.2
42	464.6	0.98	21.41	7.0
43	465.8	1.85	21.52	13.3
44	468.7	1.29	21.79	9.3
45	469.4	10.86	21.86	78.1
46	471.8	6.59	22.09	47.4
47	473.6	2.61	22.25	18.8
48	474.5	2.20	22.34	15.8
49	475.2	2.99	22.40	21.5
50	478.1	1.84	22.68	13.3
51	479.6	3.56	22.82	25.6
52	482.3	3.87	23.08	27.8
53	483.5	2.94	23.19	21.1
54	484.8	7.07	23.31	50.8
55	485.6	7.26	23.39	52.2
56	487.5	6.41	23.56	46.1
57	488.8	5.80	23.68	41.7
58	490.2	2.08	23.82	15.0
59	492.4	6.56	24.03	47.2
60	494.3	1.78	24.21	12.8
61	495.4	4.38	24.31	31.5
62	496.4	3.21	24.40	23.1
63	497.7	1.77	24.53	12.7
64	498.4	1.82	24.59	13.0
65	500.2	2.38	24.76	17.1
66	501.0	2.25	24.83	16.1
67	504.6	0.89	25.18	6.4
68	507.0	1.44	25.40	10.3
69	508.2	0.76	25.51	5.5
70	508.9	1.11	25.58	8.0

TABLE B.18 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	512.5	13.32	25.93	95.7
72	516.3	1.23	26.28	8.9
73	519.5	2.18	26.58	15.6
74	520.5	0.99	26.67	7.1
75	522.2	8.12	26.83	58.4
76	524.3	3.96	27.03	28.5
77	525.9	2.93	27.18	21.0
78	529.4	6.00	27.52	43.1
79	531.6	1.10	27.73	7.9
80	533.3	1.87	27.89	13.4
81	534.5	1.60	27.99	11.5
82	536.0	3.78	28.14	27.2
83	536.7	1.05	28.20	7.5
84	537.2	2.10	28.25	15.1
85	538.5	4.57	28.38	32.8
86	541.2	13.58	28.62	97.7
87	542.7	2.41	28.77	17.3
88	543.7	1.54	28.86	11.0
89	544.8	6.78	28.97	48.8
90	548.2	35.42	29.29	157.6
91	550.5	15.30	29.51	68.1
92	552.4	1.39	29.68	6.1
93	553.2	1.16	29.76	5.1
94	554.1	1.15	29.84	5.1
95	555.3	1.22	29.96	5.4
96	558.5	17.01	30.26	75.7
97	561.5	8.12	30.54	36.1
98	563.5	1.49	30.73	6.6
99	564.9	13.04	30.86	58.0
00	566.8	2.31	31.04	10.3
101	567.8	7.60	31.13	33.8
102	569.3	14.80	31.28	65.9
103	572.4	1.38	31.57	6.1
104	574.1	14.51	31.73	64.5
105	576.2	1.66	31.93	7.4

TABLE B.18 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	579.4	1.42	32.23	6.3
107	581.6	2.70	32.44	12.0
108	585.2	6.04	32.78	26.9
109	585.9	5.83	32.84	25.9
110	587.1	1.44	32.96	6.4
111	589.1	1.22	33.15	5.4
112	589.9	1.79	33.22	7.9
113	592.5	6.71	33.47	29.8
114	594.6	4.76	33.66	34.2
115	595.7	6.14	33.77	44.1
116	600.0	0.78	34.17	5.6
117	601.9	2.30	34.36	16.5
118	611.6	2.05	35.27	14.8
119	612.3	4.12	35.34	29.6
120	613.8	0.82	35.48	5.9
121	615.9	5.07	35.67	36.4
122	619.6	4.05	36.02	29.1
123	622.8	1.50	36.32	10.8
124	625.3	1.19	36.56	8.5
125	629.6	0.89	36.96	6.4
126	632.5	1.38	37.23	9.9
127	638.2	0.93	37.77	6.6
128	641.3	1.00	38.07	7.2
129	645.3	5.86	38.44	42.2
130	653.4	0.70	39.21	5.0

TABLE B.18 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
131	657.7	1.33	39.61	9.6
132	662.5	0.70	40.07	5.0
133	669.3	0.94	40.71	6.7
134	690.7	2.16	42.73	15.5
135	704.2	1.19	43.99	8.5

RI/CONC REPORT

Sample file : 51675h532.001a

COMMENTS : HP 675F 532Hr 1ul no spk
splss

Total concentration : 840.843 ppm

Total number of peaks interpreted : 135

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.19 2-Methylpyridine Degradation:
675°F, 678 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	11.33	15.08	81.5
2	399.5	2.73	15.29	19.6
3	401.2	2.49	15.43	17.9
4	403.6	7.14	15.66	51.3
5	404.2	7.31	15.72	52.5
6	407.8	54.65	16.06	392.9
7	409.6	14.96	16.23	107.6
8	412.3	13.46	16.48	96.7
9	413.0	6.67	16.55	47.9
10	415.8	45.71	16.81	328.7
11	419.4	93.09	17.16	669.3
12	420.5	14.66	17.25	105.4
13	421.8	1.66	17.38	11.9
14	424.7	6.58	17.65	47.3
15	425.9	1.12	17.76	8.1
16	427.0	1.26	17.86	9.0
17	428.2	0.84	17.98	6.0
18	429.9	33.21	18.14	238.8
19	431.8	2.86	18.32	20.5
20	433.2	2.27	18.45	16.3
21	434.8	24.50	18.60	176.1
22	437.3	24.16	18.84	173.7
23	438.5	10.98	18.95	78.9
24	439.8	19.23	19.07	138.3
25	441.1	2.30	19.19	16.5
26	442.3	11.54	19.31	83.0
27	447.0	15.57	19.75	111.9
28	449.2	5.74	19.96	41.2
29	450.0	10.57	20.03	76.0
30	453.8	9.83	20.40	70.7
31	455.1	1.27	20.52	9.1
32	455.6	1.61	20.56	11.6
33	456.4	24.00	20.64	172.5
34	458.9	3.12	20.87	22.4
35	459.8	9.12	20.96	65.6

TABLE B.19 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	461.4	0.98	21.11	7.1
37	462.5	4.21	21.21	30.2
38	465.2	2.18	21.47	15.6
39	467.6	0.96	21.69	6.9
40	469.4	15.28	21.86	109.8
41	471.8	7.20	22.09	51.8
42	473.5	3.26	22.25	23.4
43	474.4	2.70	22.34	19.4
44	475.2	3.11	22.41	22.3
45	478.0	2.11	22.67	15.2
46	479.6	2.37	22.82	17.0
47	480.3	0.91	22.89	6.5
48	482.3	3.29	23.08	23.7
49	483.4	2.82	23.18	20.3
50	484.7	9.39	23.30	67.5
51	485.6	7.08	23.39	50.9
52	487.4	8.21	23.56	59.0
53	488.7	6.44	23.68	46.3
54	490.2	2.07	23.82	14.9
55	490.9	1.25	23.89	9.0
56	492.4	6.81	24.03	48.9
57	494.3	1.92	24.20	13.8
58	495.3	6.07	24.31	43.6
59	496.3	4.06	24.39	29.2
60	497.7	1.94	24.52	13.9
61	498.4	2.84	24.60	20.4
62	500.2	3.44	24.76	24.7
63	500.9	2.57	24.83	18.4
64	506.0	0.83	25.31	6.0
65	506.9	1.81	25.39	13.0
66	511.7	8.15	25.85	58.6
67	512.5	10.21	25.92	73.4
68	516.5	2.72	26.30	19.5
69	519.3	6.15	26.56	44.2
70	520.3	1.50	26.66	10.8

TABLE B.19 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	522.1	10.49	26.83	75.4
72	524.3	3.68	27.03	26.5
73	525.8	1.15	27.18	8.3
74	526.8	1.92	27.27	13.8
75	529.3	7.56	27.51	54.3
76	531.7	0.75	27.73	5.3
77	533.2	0.77	27.87	5.6
78	534.6	1.06	28.00	7.6
79	535.7	11.50	28.11	82.7
80	538.5	4.54	28.37	32.7
81	541.2	19.35	28.62	139.1
82	542.7	2.82	28.76	20.3
83	543.8	1.13	28.87	8.1
84	544.8	6.11	28.97	43.9
85	548.2	47.08	29.28	209.5
86	550.5	17.58	29.51	78.2
87	557.1	1.22	30.13	5.4
88	558.5	25.56	30.26	113.7
89	561.5	10.77	30.54	47.9
90	563.7	3.75	30.74	16.6
91	564.9	15.39	30.86	68.5
92	566.8	3.00	31.04	13.3
93	567.8	11.64	31.13	51.8
94	569.4	20.26	31.28	90.1
95	572.5	3.51	31.57	15.6
96	574.1	16.96	31.73	75.5
97	574.8	7.94	31.79	35.3
98	576.2	2.27	31.93	10.1
99	579.3	1.50	32.22	6.6
100	581.7	3.45	32.44	15.3
101	583.6	1.32	32.62	5.9
102	585.2	10.50	32.77	46.7
103	586.0	8.02	32.84	35.7
104	587.0	1.94	32.94	8.6
105	587.9	1.28	33.02	5.7

TABLE B.19 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	589.1	2.09	33.14	9.3
107	589.9	2.81	33.21	12.5
108	592.5	8.88	33.45	39.5
109	594.6	6.55	33.66	47.1
110	595.7	9.09	33.76	65.4
111	600.0	1.15	34.17	8.2
112	602.1	3.37	34.36	24.2
113	603.9	0.95	34.53	6.8
114	609.4	0.76	35.05	5.5
115	610.6	0.77	35.16	5.6
116	611.6	2.62	35.26	18.8
117	612.5	4.26	35.34	30.6
118	615.9	3.62	35.66	26.0
119	623.0	1.24	36.33	8.9
120	625.4	1.02	36.56	7.3
121	631.0	0.97	37.09	7.0
122	632.6	1.98	37.24	14.3
123	640.9	1.40	38.01	10.0
124	645.5	7.84	38.45	56.4
125	646.9	1.68	38.58	12.1
126	652.4	0.69	39.10	5.0
127	655.2	0.69	39.36	5.0
128	657.8	2.29	39.61	16.5
129	662.7	1.55	40.07	11.2
130	664.8	1.21	40.27	8.7

TABLE B.19 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
131	669.4	2.67	40.70	19.2
132	679.1	0.72	41.62	5.2
133	691.0	2.93	42.73	21.0
134	704.4	1.19	44.00	8.5

RI/CONC REPORT

Sample file : 52675h678.001a

COMMENTS : HP 675F 678Hr 1ul no spk
splss

Total concentration : 1009.79 ppm

Total number of peaks interpreted : 134

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.20 2-Methylpyridine Degradation:
675°F, 850 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	8.57	15.07	61.6
2	399.0	5.06	15.25	36.4
3	401.1	3.43	15.43	24.6
4	403.6	9.08	15.66	65.3
5	407.9	60.30	16.07	433.5
6	409.8	23.21	16.25	166.9
7	412.4	9.29	16.49	66.8
8	413.2	4.77	16.57	34.3
9	414.4	3.39	16.68	24.4
10	415.9	38.88	16.82	279.5
11	417.9	6.88	17.01	49.4
12	419.6	97.17	17.17	698.7
13	422.0	0.78	17.39	5.6
14	424.9	7.33	17.66	52.7
15	426.2	1.19	17.79	8.5
16	427.5	2.67	17.91	19.2
17	428.5	2.65	18.01	19.0
18	430.0	35.35	18.15	254.1
19	432.0	3.97	18.34	28.5
20	433.2	4.73	18.45	34.0
21	435.0	23.27	18.62	167.3
22	436.7	2.64	18.78	19.0
23	437.5	22.26	18.85	160.0
24	438.7	10.89	18.97	78.3
25	439.9	20.64	19.09	148.4
26	441.2	1.74	19.20	12.5
27	442.5	12.33	19.33	88.7
28	447.1	18.02	19.76	129.6
29	449.2	4.91	19.96	35.3
30	450.1	9.53	20.04	68.5
31	454.0	9.49	20.41	68.2
32	455.8	3.03	20.58	21.7
33	456.6	23.69	20.66	170.3
34	458.8	3.68	20.86	26.5
35	460.0	8.98	20.97	64.6

TABLE B.20 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	461.4	0.87	21.11	6.3
37	462.6	5.36	21.22	38.5
38	465.3	0.93	21.48	6.7
39	467.7	1.12	21.71	8.0
40	468.7	1.40	21.80	10.1
41	469.5	15.00	21.87	107.8
42	471.8	8.53	22.09	61.3
43	473.6	2.88	22.26	20.7
44	474.6	2.79	22.35	20.1
45	475.3	3.32	22.42	23.8
46	478.0	2.04	22.68	14.6
47	479.7	2.20	22.84	15.8
48	480.5	0.74	22.91	5.3
49	482.4	3.09	23.08	22.2
50	483.4	2.86	23.18	20.6
51	484.8	10.05	23.31	72.3
52	485.7	7.39	23.40	53.1
53	487.5	8.05	23.57	57.9
54	488.8	6.38	23.69	45.9
55	490.2	1.71	23.82	12.3
56	492.6	5.67	24.05	40.8
57	494.4	1.84	24.22	13.2
58	495.4	6.23	24.32	44.8
59	496.4	3.53	24.41	25.4
60	497.8	1.51	24.54	10.9
61	498.4	2.37	24.60	17.0
62	500.2	4.03	24.77	28.9
63	501.0	2.94	24.84	21.1
64	504.7	1.28	25.19	9.2
65	506.0	1.12	25.31	8.1
66	506.9	2.13	25.40	15.3
67	511.8	2.87	25.86	20.6
68	512.6	7.55	25.93	54.3
69	516.6	2.13	26.31	15.3
70	519.4	6.02	26.58	43.2

TABLE B.20 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	520.5	2.27	26.68	16.3
72	522.2	10.76	26.84	77.4
73	524.4	5.74	27.05	41.2
74	525.9	2.36	27.19	17.0
75	527.1	1.21	27.30	8.7
76	529.4	9.89	27.52	71.1
77	531.8	4.02	27.75	28.9
78	533.2	3.07	27.88	22.1
79	534.6	2.29	28.01	16.4
80	535.8	15.52	28.12	111.6
81	538.5	8.03	28.38	57.7
82	541.2	28.50	28.63	204.9
83	544.9	8.54	28.98	61.4
84	548.2	59.56	29.29	265.0
85	550.6	23.70	29.51	105.4
86	552.8	5.37	29.72	23.9
87	555.3	1.75	29.96	7.8
88	557.2	5.50	30.14	24.4
89	558.5	28.96	30.26	128.9
90	561.5	12.58	30.54	55.9
91	563.6	2.94	30.74	13.0
92	565.0	15.45	30.87	68.7
93	566.8	3.44	31.04	15.3
94	567.8	14.36	31.14	63.9
95	569.4	22.94	31.28	102.1
96	572.5	3.77	31.58	16.8
97	573.0	1.65	31.62	7.3
98	574.2	29.38	31.74	130.7
99	576.3	2.51	31.94	11.2
00	577.8	1.57	32.08	7.0
101	579.4	3.26	32.23	14.5
102	581.7	4.66	32.44	20.7
103	583.3	3.02	32.60	13.4
104	584.4	2.14	32.70	9.5
105	585.2	10.35	32.78	46.0

TABLE B.20 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	586.0	7.92	32.85	35.2
107	587.1	2.26	32.95	10.0
108	587.9	1.37	33.03	6.1
109	589.2	2.62	33.15	11.6
110	589.9	3.16	33.22	14.1
111	592.4	8.75	33.46	38.9
112	594.7	5.82	33.67	41.9
113	595.7	10.14	33.77	72.9
114	600.1	1.06	34.18	7.6
115	602.1	2.23	34.37	16.0
116	609.3	0.73	35.05	5.2
117	611.7	2.17	35.27	15.6
118	612.4	4.72	35.34	33.9
119	615.9	3.18	35.67	22.9
120	619.7	2.79	36.02	20.1
121	621.1	1.23	36.16	8.8
122	622.8	1.63	36.32	11.7
123	625.4	1.27	36.56	9.1
124	632.7	2.24	37.25	16.1
125	638.2	2.31	37.77	16.6
126	640.7	1.74	38.01	12.5
127	645.4	7.16	38.45	51.5
128	646.8	1.65	38.58	11.9
129	652.2	0.75	39.09	5.4
130	655.1	0.70	39.36	5.0

TABLE B.20 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
131	657.7	1.58	39.61	11.3
132	662.5	0.89	40.07	6.4
133	669.3	2.53	40.70	18.2
134	690.9	3.10	42.74	22.3

RI/CONC REPORT

Sample file : 53675h850.001a

COMMENTS : HP 675F 850Hr 1ul no spk
splss

Total concentration : 1091.17 ppm

Total number of peaks interpreted : 134

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.21 2-Methylpyridine Degradation:
675°F, 921 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	8.88	15.11	63.8
2	399.8	1.28	15.34	9.2
3	401.1	1.32	15.46	9.5
4	403.6	3.80	15.70	27.3
5	404.4	1.02	15.77	7.3
6	406.5	8.28	15.97	59.5
7	407.8	48.81	16.09	350.9
8	409.7	10.76	16.27	77.3
9	412.3	8.60	16.52	61.8
10	413.1	5.54	16.59	39.8
11	414.6	1.05	16.73	7.5
12	415.8	35.47	16.84	255.0
13	418.1	3.15	17.06	22.6
14	419.4	72.78	17.19	523.3
15	420.5	13.78	17.29	99.1
16	421.8	0.76	17.41	5.4
17	424.7	6.16	17.69	44.3
18	427.0	0.78	17.90	5.6
19	428.2	0.81	18.02	5.8
20	429.9	29.56	18.17	212.5
21	431.7	5.85	18.34	42.0
22	433.2	3.63	18.48	26.1
23	434.8	19.79	18.63	142.3
24	437.3	20.06	18.87	144.2
25	438.5	10.58	18.98	76.1
26	439.8	19.82	19.10	142.5
27	442.3	12.22	19.34	87.9
28	447.0	15.21	19.78	109.4
29	449.1	4.04	19.98	29.1
30	449.9	8.50	20.06	61.1
31	452.9	0.98	20.34	7.1
32	454.0	6.97	20.45	50.1
33	456.5	22.12	20.68	159.1
34	458.7	4.47	20.88	32.1
35	459.7	9.90	20.98	71.2

TABLE B.21 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	461.2	1.44	21.12	10.3
37	462.5	7.39	21.24	53.1
38	465.3	1.54	21.51	11.1
39	467.6	1.16	21.72	8.3
40	469.3	15.23	21.89	109.5
41	471.8	7.34	22.12	52.8
42	473.4	2.28	22.27	16.4
43	474.3	3.21	22.36	23.0
44	478.0	2.19	22.70	15.7
45	479.4	2.26	22.84	16.3
46	480.1	1.15	22.90	8.2
47	482.2	2.85	23.10	20.5
48	483.4	2.42	23.21	17.4
49	484.8	5.95	23.34	42.8
50	485.5	8.92	23.41	64.1
51	487.3	8.37	23.58	60.2
52	488.6	7.06	23.70	50.8
53	490.1	2.26	23.85	16.2
54	492.3	2.59	24.05	18.6
55	492.9	2.68	24.11	19.2
56	494.3	2.07	24.24	14.9
57	495.2	6.13	24.32	44.0
58	496.3	3.48	24.43	25.0
59	497.6	1.44	24.55	10.4
60	498.4	1.90	24.62	13.7
61	500.1	2.94	24.78	21.1
62	500.7	2.17	24.84	15.6
63	504.6	0.71	25.20	5.1
64	505.8	0.89	25.32	6.4
65	506.8	1.74	25.42	12.5
66	510.3	1.94	25.75	14.0
67	512.4	14.51	25.94	104.3
68	516.3	2.11	26.31	15.1
69	519.4	7.20	26.60	51.8
70	522.1	10.75	26.85	77.3

TABLE B.21 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	524.2	3.46	27.05	24.9
72	525.7	1.25	27.19	9.0
73	529.3	7.15	27.53	51.4
74	531.7	3.19	27.76	23.0
75	533.0	2.47	27.88	17.7
76	535.7	8.58	28.14	61.7
77	538.4	4.70	28.39	33.8
78	541.1	19.76	28.64	142.0
79	544.8	7.73	29.00	34.4
80	548.1	46.04	29.30	204.9
81	550.5	16.79	29.53	74.7
82	557.2	1.47	30.16	6.5
83	558.5	22.94	30.28	102.0
84	561.5	9.29	30.56	41.3
85	563.4	2.19	30.75	9.7
86	564.8	14.02	30.88	62.3
87	566.7	3.04	31.05	13.5
88	567.7	12.44	31.15	55.3
89	569.2	20.93	31.29	93.1
90	572.3	2.61	31.58	11.6
91	574.1	10.43	31.75	46.4
92	574.9	11.08	31.82	49.3
93	576.1	1.97	31.94	8.7
94	577.8	1.39	32.10	6.2
95	579.3	1.66	32.25	7.4
96	581.6	2.75	32.46	12.2
97	583.3	1.74	32.62	7.7
98	585.2	5.29	32.80	23.5
99	585.8	7.72	32.86	34.3
00	587.0	1.60	32.97	7.1
101	589.1	1.25	33.17	5.5
102	589.9	2.21	33.24	9.8
103	592.3	3.98	33.46	17.7
104	594.6	2.63	33.68	18.9
105	595.6	8.25	33.78	59.3

TABLE B.21 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	599.2	5.08	34.12	36.5
107	602.1	1.88	34.39	13.5
108	611.7	1.25	35.29	9.0
109	612.4	3.09	35.36	22.2
110	614.2	1.10	35.53	7.9
111	615.9	2.00	35.69	14.4
112	619.6	1.95	36.03	14.0
113	621.0	1.37	36.17	9.8
114	622.8	1.28	36.34	9.2
115	625.3	0.75	36.57	5.3
116	632.4	0.81	37.24	5.8
117	645.3	4.79	38.46	34.4
118	691.1	2.17	42.77	15.6
119	704.2	1.33	44.00	9.5

RI/CONC REPORT

Sample file : 56675h921.001a

COMMENTS : HP 675f 921Hr lul no spk
splss

Total concentration : 878.42 ppm

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

**TABLE B.22 2-Methylpyridine Degradation:
675°F, 993 h**

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
1	396.4	8.83	15.07	71.6
2	398.7	1.24	15.23	10.0
3	399.6	1.11	15.30	9.0
4	401.2	3.30	15.44	26.7
5	403.6	12.30	15.66	99.7
6	405.6	2.15	15.85	17.4
7	407.9	45.14	16.07	365.7
8	409.7	10.36	16.24	83.9
9	410.7	1.42	16.33	11.5
10	412.3	10.66	16.48	86.4
11	413.2	4.96	16.56	40.1
12	414.4	2.37	16.68	19.2
13	415.1	3.40	16.75	27.5
14	415.9	40.14	16.82	325.2
15	419.6	82.14	17.17	665.4
16	421.9	0.62	17.39	5.0
17	422.6	0.85	17.45	6.9
18	424.8	6.20	17.65	50.2
19	427.1	1.32	17.88	10.7
20	430.0	30.84	18.14	249.8
21	431.9	3.96	18.32	32.1
22	433.1	4.20	18.44	34.0
23	434.9	19.28	18.61	156.1
24	437.4	21.36	18.84	173.0
25	438.7	9.88	18.96	80.0
26	439.9	17.49	19.08	141.7
27	441.2	2.42	19.20	19.6
28	442.4	13.19	19.32	106.8
29	447.1	14.52	19.75	117.6
30	449.2	3.83	19.95	31.0
31	450.1	8.88	20.04	71.9
32	453.2	4.30	20.33	34.8
33	453.9	9.03	20.39	73.1
34	456.5	20.19	20.64	163.5
35	459.9	10.34	20.96	83.8

TABLE B.22 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
36	461.4	0.67	21.11	5.4
37	462.5	4.80	21.21	38.9
38	465.2	2.19	21.46	17.7
39	467.7	0.80	21.70	6.5
40	469.4	14.64	21.85	118.6
41	471.7	7.51	22.07	60.8
42	473.6	2.41	22.25	19.5
43	474.6	2.02	22.34	16.4
44	475.3	2.35	22.41	19.0
45	478.0	2.02	22.67	16.3
46	479.6	2.13	22.82	17.3
47	480.5	1.08	22.90	8.7
48	482.3	3.27	23.07	26.5
49	483.3	2.28	23.16	18.5
50	484.6	9.56	23.29	77.4
51	485.7	5.13	23.39	41.5
52	487.4	7.81	23.55	63.2
53	488.8	8.11	23.68	65.7
54	490.9	2.07	23.88	16.8
55	492.6	4.81	24.04	39.0
56	494.3	2.27	24.20	18.4
57	495.3	5.97	24.30	48.3
58	496.3	3.42	24.39	27.7
59	497.7	1.46	24.52	11.8
60	498.4	2.13	24.58	17.2
61	500.1	3.24	24.75	26.2
62	500.9	2.22	24.82	17.9
63	504.7	1.62	25.18	13.2
64	506.1	1.30	25.31	10.5
65	506.8	3.23	25.38	26.2
66	511.7	7.82	25.83	63.4
67	512.5	8.97	25.92	72.7
68	514.8	0.86	26.13	6.9
69	516.4	2.38	26.28	19.3
70	517.8	0.82	26.42	6.7

TABLE B.22 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
71	518.6	1.50	26.49	12.1
72	519.3	4.22	26.55	34.2
73	520.5	1.62	26.66	13.1
74	522.1	9.96	26.82	80.7
75	524.3	3.45	27.02	27.9
76	525.8	1.41	27.17	11.4
77	529.4	5.72	27.50	46.3
78	533.0	1.42	27.84	11.5
79	535.7	7.83	28.09	63.4
80	537.3	0.80	28.25	6.5
81	538.5	4.87	28.36	39.4
82	541.2	21.53	28.61	174.4
83	542.6	3.15	28.75	25.5
84	543.7	1.89	28.85	15.3
85	544.8	5.88	28.95	47.6
86	548.2	56.05	29.27	274.0
87	550.5	20.53	29.49	100.3
88	553.3	1.82	29.75	8.9
89	557.0	1.60	30.10	7.8
90	558.4	27.40	30.24	133.9
91	561.4	10.29	30.52	50.3
92	563.6	2.08	30.72	10.1
93	564.9	13.56	30.84	66.2
94	566.7	3.23	31.02	15.8
95	567.7	14.65	31.11	71.6
96	569.3	21.56	31.26	105.4
97	572.5	3.83	31.56	18.7
98	574.1	22.99	31.71	112.4
99	575.0	6.76	31.80	33.0
100	576.3	2.35	31.92	11.5
101	577.6	1.26	32.04	6.1
102	579.4	1.14	32.21	5.5
103	581.8	3.34	32.43	16.3
104	583.7	1.40	32.61	6.8
105	585.2	11.38	32.75	55.6

TABLE B.22 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
106	586.0	6.89	32.83	33.7
107	587.3	2.55	32.95	12.5
108	587.9	1.38	33.01	6.7
109	589.0	3.36	33.11	16.4
110	589.9	3.05	33.20	14.9
111	592.5	10.40	33.44	50.8
112	594.6	5.73	33.64	46.4
113	595.6	9.79	33.74	79.3
114	602.1	1.85	34.35	15.0
115	606.7	0.62	34.78	5.0
116	609.5	0.80	35.04	6.5
117	611.5	2.35	35.24	19.0
118	612.4	5.12	35.32	41.5
119	614.4	1.18	35.50	9.6
120	615.9	2.81	35.64	22.7
121	619.4	1.80	35.97	14.6
122	619.6	1.32	36.00	10.7
123	621.1	0.90	36.13	7.3
124	622.9	1.00	36.31	8.1
125	625.4	1.44	36.54	11.6
126	629.0	0.80	36.88	6.5
127	631.0	0.83	37.07	6.7
128	632.6	2.65	37.21	21.5
129	638.1	2.78	37.74	22.5
130	640.1	0.82	37.92	6.6
131	641.4	0.82	38.05	6.6
132	645.5	7.09	38.43	57.4
133	646.9	1.90	38.56	15.3
134	649.3	1.56	38.79	12.6
135	652.4	0.98	39.08	7.9
136	653.7	0.89	39.20	7.2
137	655.2	0.64	39.35	5.2
138	657.7	1.99	39.58	16.1
139	661.7	0.98	39.96	7.9
140	662.5	1.30	40.04	10.5

TABLE B.22 (Cont'd)

Peak No.	Aromatic Retention Index	Conc. (ppm)	Ret. Time (min)	Area ^a
141	664.7	0.72	40.24	5.8
142	669.4	2.49	40.68	20.2
143	674.5	0.84	41.16	6.8
144	679.1	0.72	41.59	5.9
145	686.4	0.85	42.28	6.9
146	691.0	3.54	42.71	28.7
147	697.0	3.35	43.28	27.1
148	697.5	1.91	43.33	15.4
149	698.5	6.05	43.42	49.0
150	700.8	1.51	43.63	12.2
151	704.5	1.21	43.98	9.8

RI/CONC REPORT

Sample file : 42675h993.001a

COMMENTS : HP 675F 993Hr lul no spk
splss

Total concentration : 982.371 ppm

Total number of peaks interpreted : 151

^aArea is in a unit that is calibrated
when the standard sample is analyzed.

APPENDIX C:
GAS CHROMATOGRAMS
FOR HIGH BOILERS

Figures C.1-C.43 are the gas chromatograms in the high-boiling region of each liquid sample analyzed. All y-axes in the figures are in millivolts (mV); all x-axes are in minutes.

FIGURE C.1 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 0 h

FIGURE C.2 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 0 h, scale expanded 5x

FIGURE C.3 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 18 h

FIGURE C.4 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 18 h, scale expanded 5x for 30-45 min

FIGURE C.5 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 161 h

FIGURE C.6 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 161 h, scale expanded 5x for 30-45 min

FIGURE C.7 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 329 h

FIGURE C.8 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 329 h, scale expanded 2.5x for 30-45 min

FIGURE C.9 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 531 h

FIGURE C.10 Replotted Chromatograms of High-Boiler Degradation Products: 575°F, 531 h, scale expanded 2.5x for 30-45 min

FIGURE C.11 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 21 h

FIGURE C.12 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 21 h, scale expanded .4x for 30-45 min

FIGURE C.13 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 189 h

FIGURE C.14 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 189 h, scale expanded 4x for 30-45 min

FIGURE C.15 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 359 h

FIGURE C.16 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 359 h, scale expanded 2.5x for 30-45 min

FIGURE C.17 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 525 h

FIGURE C.18 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 525 h, scale expanded 2.5x for 30-45 min

FIGURE C.19 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 694 h

FIGURE C.20 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 694 h, scale expanded 2x for 30-45 min

FIGURE C.21 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 837 h

FIGURE C.22 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 837 h, scale expanded 1.25x for 30-45 min

FIGURE C.23 Replotted Chromatograms of High-Boiler Degradation Products: 625°F, 1153 h

FIGURE C.24 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 0 h

FIGURE C.25 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 0 h, scale expanded 2x for 15-30 min and 5x for 30-45 min

FIGURE C.26 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 22 h

FIGURE C.27 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 22 h, scale expanded 4x for 30-45 min

FIGURE C.28 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 191 h

FIGURE C.29 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 191 h, scale expanded 4x for 30-45 min

FIGURE C.30 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 359 h

FIGURE C.31 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 359 h, scale expanded 4x for 30-45 min

FIGURE C.32 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 514 h

FIGURE C.33 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 514 h, scale expanded 4x for 30-45 min

FIGURE C.34 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 532 h

FIGURE C.35 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 532 h, scale expanded 4x for 30-45 min

FIGURE C.36 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 678 h

FIGURE C.37 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 678 h, scale expanded 2.5x for 30-45 min

FIGURE C.38 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 850 h

FIGURE C.39 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 850 h, scale expanded 2.5x for 30-45 min

FIGURE C.40 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 921 h

FIGURE C.41 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 921 h, scale expanded 2.5x for 30-45 min

FIGURE C.42 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 993 h

FIGURE C.43 Replotted Chromatograms of High-Boiler Degradation Products: 675°F, 993 h, scale expanded 2.5x for 30-45 min

APPENDIX D:
IDENTIFICATIONS OF SELECTED IMPURITIES
AND DEGRADATION PRODUCTS

Figures D.1-D.9 are the Fourier-transform infrared (FTIR) spectroscopic identifications of significant impurities and degradation products.

FIGURE D.1 Impurity in the 575°F, 18-h Sample

FIGURE D.2 Infrared Spectrum of Ammonia, Analytical Sample, Compared to EPA Library Match

FIGURE D.3 Infrared Spectrum of C₄-Alkene, Analytical Sample

FIGURE D.4 Infrared Spectrum of Acetone, Analytical Sample, Compared to EPA Library Match

FIGURE D.5 Infrared Spectrum of Acetic Acid, Analytical Sample, Compared to EPA Library Match

FIGURE D.6 Infrared Spectrum of Formic Acid, Analytical Sample, Compared to EPA Library Match

FIGURE D.7 Infrared Spectrum of Acetamide, Analytical Sample, Compared to EPA Library Match

FIGURE D.8 Infrared Spectrum of N-Ethyl Acetamide, Analytical Sample, Compared to EPA Library Match

FIGURE D.9 Infrared Spectrum of Acetonitrile, 675°F 991-h Sample, Compared to EPA Library Match

APPENDIX E:
DEGRADATION REPORTS
FOR LOW BOILERS

Tables E.1-E.23 show the concentration (ppm) of each low-boiling impurity and degradation component and the total concentration (ppm) of all such components. In addition, the tables show the aromatic retention index of each degradation product, names of the major degradation products, and the retention time (min) and area of each product.

TABLE E.1 2-Methylpyridine Degradation: 575°F and 625°F, Initial Material

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	12.5	1.41	1.02	35.6
2		14.2	5.64	1.16	142.7
3		20.8	0.50		
4		23.0	7.61	1.88	192.3
5		24.4	29.32	1.99	741.1
6		26.3	34.14	2.15	862.7
7		31.7	2.94	2.59	74.3
8		39.1	5.78	3.19	146.0
9		3.1	7.44	3.52	188.2
10		48.5	10.65	3.97	269.3
11	Pyridine region	51.7	17.74	4.23	448.4
12		58.5	225.72	4.78	5704.0
13		66.4	108.55	5.43	2743.1
14		69.2	391.38	5.66	9890.1
15		81.4	41.17	6.66	1040.4
16		85.2	81.38	6.96	2056.7
17		87.7	244.89	7.17	6188.4
18		193.8	159.73	15.85	4036.5
19		194.9	24.89	15.94	629.0
20		200.0	2827.93	16.36	71461.0
21	4-Methylpyridine	204.9	14.51	16.71	366.7
22		207.4	2.64	16.89	66.8
23		214.7	0.58	17.42	14.7
24		220.4	0.51	17.83	13.0
25		221.6	6.30	17.92	159.3
26		226.7	0.25	18.29	6.4
27		237.3	134.36	19.05	3395.3
28		246.6	0.85	19.72	21.5
29		247.6	1.04		
30		250.8	29.52	20.03	746.0
31	Formic acid	257.6	3.09	20.52	78.1
32		261.0	0.21	20.76	5.3
33		262.2	0.47	20.85	12.0
34		294.2	0.34	23.16	8.7
35		296.5	1.14	23.32	28.8
36		305.9	0.18	24.00	4.6
37		308.9	0.14	24.22	3.7
38		312.1	0.13	24.45	3.3
39		325.6	0.14	25.43	3.5
40		332.9	0.24	25.95	6.0
41		336.2	0.41	26.19	10.4
42		342.5	2.15	26.65	54.5
43		346.3	0.17	26.92	4.3
44		368.8	0.20	28.54	5.1

TABLE E.1 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
45		374.9	0.18	28.98	4.7
46		383.2	0.48		
47		386.5	1.03	29.82	26.0
48		394.8	0.12	30.42	3.0
49		400.3	0.22	30.84	5.7
50		401.8	2.41	31.06	60.9
51		403.9	0.17	31.38	4.4
52		405.4	0.40	31.60	10.2
53		406.3	0.66	31.73	16.7
54		409.2	0.63	32.18	15.9
55		413.0	0.16		
56		417.8	1.35	33.47	34.2
57		421.0	0.24	33.95	6.1
58		424.1	0.46	34.41	11.8
59		427.1	0.73	34.86	18.4
Total concentration: 4437.86 ppm					

RI/CONC REPORT

Sample file: 66P575000.001a

COMMENTS: initial material for 575 and 625°F

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.2 2-Methylpyridine Degradation: 575°F, 18 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.2	1.21	0.94	30.8
2		11.9	2.09	1.00	53.0
3		12.2	7.16	1.02	181.5
4		13.9	5.62	1.16	142.4
5		15.0	28.76	1.26	728.2
6		20.2	28.07		
7		22.3	8.07	1.88	204.4
8		23.7	21.19	1.99	536.5
9		25.7	32.77	2.16	829.8
10		30.7	2.92	2.58	74.0
11		39.2	2.57	3.30	65.1
12		41.7	2.09	3.51	52.9
13		49.6	4.63	4.17	117.3
14		55.8	0.37	4.69	9.4
15	Pyridine region	64.2	32.53		
16		67.0	70.30	5.64	1780.1
17		69.9	77.60	5.88	1964.9
18		85.0	5.74	7.15	145.3
19		92.1	17.54	7.75	444.2
20	3-Methylpyridine	194.7	233.50	16.38	5912.2
21		196.0	29.33	16.49	742.6
22	4-Methylpyridine	200.0	3085.46	16.83	78122.1
23		204.5	16.85	17.14	426.6
24		206.8	4.69	17.29	118.9
25		213.9	1.01	17.77	25.6
26		219.5	0.80	18.16	20.4
27		220.8	7.42	18.25	187.9
28		225.8	0.40	18.59	10.1
29		230.8	4.70	18.93	119.1
30		236.5	176.37	19.31	4465.6
31		245.8	1.13	19.94	28.7
32	Formic acid	249.4	66.98		
33		257.7	4.69	20.76	118.7
34		262.0	1.72	21.05	43.6
35		283.7	9.80	22.53	248.1
36	C2-Pyridine	296.9	9.91	23.43	250.9
37		310.3	44.79	24.34	1134.1
38		322.7	0.63	25.19	16.2
39		327.3	0.55	25.50	14.0
40		333.2	10.28	25.90	260.2
41		344.9	5.88	26.70	148.9
42		348.6	10.44	26.95	264.3
43		355.9	0.36	27.45	9.2
44		369.3	0.11	28.36	3.0
45		372.6	1.71	28.59	43.5
46		380.4	0.56	29.12	14.2

TABLE E.2 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		384.3	0.53	29.38	13.4
48		391.2	0.59	29.85	15.1
49		399.6	1.19	30.42	30.2
50		404.2	4.26	31.07	107.8
51		406.4	1.17	31.41	29.7
52		408.8	1.60	31.76	40.5
53		411.7	2.50	32.19	63.3
54		413.8	0.56	32.52	14.2
55		416.4	1.58	32.90	40.1
56		418.4	1.07	33.20	27.2
57		420.1	2.00	33.46	50.7
58		422.9	0.18		
59		426.5	7.09	34.41	179.6
60		429.9	13.29	34.93	336.5
Total concentration: 4119.16 ppm					

TABLE E.3 2-Methylpyridine Degradation: 575°F, 161 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.2	2.42	0.94	61.3
2		11.9	3.81	1.00	96.6
3		12.2	7.67	1.03	194.2
4		12.8	9.64	1.08	244.1
5		13.9	9.53	1.17	241.4
6		15.0	12.10	1.26	306.4
7		18.1	8.93	1.52	226.3
8		22.3	10.44	1.88	264.4
9		23.7	13.32	1.99	337.4
10		25.6	13.51	2.16	342.1
11		30.8	1.86	2.59	47.1
12		39.2	3.99	3.30	101.0
13		41.8	4.26	3.52	107.9
14		52.1	0.67	4.39	17.0
15	Pyridine region	64.0	25.25	5.40	639.5
16		66.8	127.72	5.63	3233.9
17		84.8	5.51		
18		91.7	16.30	7.73	412.9
19	3-Methylpyridine	194.7	213.00	16.42	5393.1
20		195.5	30.65	16.49	776.0
21		196.3	39.15	16.56	991.2
22	4-Methylpyridine	200.0	3151.54	16.87	79795.1
23		204.4	17.34	17.17	439.2
24		206.7	4.33	17.33	109.6
25		213.7	1.42	17.81	36.1
26		217.2	0.99	18.05	25.2
27		219.3	3.77	18.19	95.4
28		220.6	10.65	18.28	269.8
29	Acetic acid	236.7	286.36	19.37	7250.6
30		240.2	44.08	19.61	1116.3
31		245.7	10.25	19.99	259.6
32		248.3	6.67	20.17	169.0
33	Formic acid	249.5	67.68	20.25	1713.8
34		261.7	5.18	21.08	131.2
35		274.9	3.60	21.98	91.2
36		280.5	2.61	22.36	66.1
37		283.0	24.75	22.53	626.6
38		289.5	0.94	22.97	23.9
39		294.2	7.21	23.30	182.5
40	C2-Pyridine	296.5	5.85	23.45	148.3
41		310.4	230.08	24.40	5825.7
42		322.0	0.61	25.19	15.6
43		327.3	0.15		
44		332.7	24.41	25.92	618.1
45		338.5	2.39	26.31	60.6
46		343.0	10.82	26.62	274.2

TABLE E.3 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		348.2	15.84	26.97	401.0
48		355.3	2.02	27.46	51.2
49		360.9	4.73	27.84	119.8
50		364.0	1.06	28.05	26.8
51		368.8	1.05	28.38	26.7
52		372.0	14.18	28.60	359.1
53		379.7	2.25	29.12	57.0
54		383.7	4.37	29.39	110.7
55		390.4	0.32	29.85	8.2
56		394.3	1.32	30.12	33.4
57		398.7	0.44	30.42	11.3
58		403.8	2.94	31.07	74.4
59		406.1	5.84	31.42	148.0
60		408.0	9.72	31.71	246.1
61		411.2	3.36	32.19	85.2
62		413.3	3.13	32.49	79.3
63		416.1	6.02	32.91	152.4
64		420.9	3.15	33.63	79.8
65		422.6	1.48	33.89	37.4
66		426.1	1.05	34.42	26.7
67		427.7	2.50	34.65	63.5
68		429.6	5.93	34.94	150.2

Total concentration: 4576.43 ppm

RI/CONC REPORT

Sample file: 70P575161.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.4 2-Methylpyridine Degradation: 575°F, 329 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.8	1.08	0.06	27.4
2		11.9	0.59	1.00	14.9
3		12.2	2.88		
4		13.1	0.91	1.10	23.0
5		14.2	2.52	1.20	63.8
6		15.0	5.96	1.26	151.0
7		18.1	5.44	1.53	137.7
8		19.5	3.66	1.65	92.7
9		22.2	32.87	1.88	832.3
10		23.8	65.08	2.01	1648.0
11		37.6	0.71	3.18	18.0
12		39.0	3.60	3.30	91.3
13		41.8	5.34	3.53	135.4
14		47.2	3.42	3.99	86.6
15		49.6	0.90	4.20	22.8
16		50.4	0.44	4.26	11.1
17		50.9	0.43	4.31	10.9
18		57.4	0.30	4.85	7.6
19	Pyridine region	63.7	23.81	5.39	602.9
20		66.5	54.10	5.62	1369.9
21		69.0	0.12	5.83	3.1
22		69.5	7.24	5.88	183.4
23		70.2	15.22	5.94	385.5
24		71.3	39.91	6.03	1010.6
25		82.6	0.15	6.99	4.0
26		84.3	8.31	7.14	210.5
27		91.8	16.52	7.77	418.2
28		93.1	8.46	7.88	214.2
29		95.0	3.24		
30		96.1	9.43	8.13	238.8
31		99.2	3.14	8.39	79.6
32	3-Methylpyridine	100.7	4.75	8.52	120.3
33		101.6	2.58	8.60	65.4
34		194.7	212.11	16.48	5370.5
35		196.3	39.63	16.62	1003.6
36	4-Methylpyridine	200.0	3168.78	16.93	80231.7
37		204.4	13.83	17.22	350.2
38		206.6	2.52	17.38	64.0
39		213.6	1.50	17.85	37.9
40		217.4	0.85	18.11	21.6
41		219.2	8.36	18.23	211.6
42		220.5	11.78	18.32	298.3
43		225.5	1.33	18.66	33.8
44	Acetic acid	236.7	351.11	19.42	8890.0
45		240.1	65.32	19.65	1653.9
46		245.7	20.51		

TABLE E.4 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47	Formic acid	249.5	82.52	20.29	2089.4
48		257.3	0.26	20.82	6.7
49		261.4	7.80	21.10	197.7
50		269.0	0.38	21.61	9.6
51		274.5	3.41	21.99	86.4
52		277.0	1.55	22.16	39.3
53		279.9	2.74	22.35	69.6
54		282.6	33.38	22.53	845.2
55		293.7	11.96		
56		310.0	314.87	24.40	7972.5
57		321.2	0.73	25.16	18.6
58		326.9	2.02	25.55	51.2
59		334.0	30.44	26.02	770.9
60		337.8	5.32	26.28	134.8
61		342.6	17.53	26.61	444.0
62	C2-Pyridine	347.7	13.61	26.95	344.7
63		355.3	2.69	27.47	68.1
64		360.7	10.63	27.84	269.2
65		368.7	1.58	28.38	40.1
66		371.9	18.25	28.60	462.2
67		379.5	2.99	29.11	75.9
68		383.5	5.00	29.39	126.6
69		394.1	0.65	30.11	16.6
70		403.6	0.88	31.05	22.4
71		406.1	6.74	31.42	170.6
72		408.0	22.11		
73		411.1	3.11	32.17	78.7
74		413.2	3.20	32.48	81.2
75		416.0	3.35	32.91	85.0
76		417.8	0.77	33.17	19.5
77		421.1	5.35	33.66	135.4
78		426.1	0.58	34.41	14.7
79		427.6	1.37	34.64	34.7
80		429.2	6.67	34.87	169.1

Total concentration: 4855.55 ppm

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Sample file: 71P575329.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.5 2-Methylpyridine Degradation: 575°F, 532 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	10.6	0.12	0.89	3.2
2		10.8	3.83	0.91	97.0
3		11.1	10.11	0.94	256.2
4		12.1	16.24	1.02	411.2
5		12.3	5.19	1.04	131.6
6		12.5	3.08	1.06	78.0
7		12.8	3.89	1.08	98.5
8		13.4	4.94	1.13	125.2
9		13.8	4.87	1.16	123.5
10		14.5	3.52	1.22	89.3
11		14.9	6.96		
12		15.6	32.86	1.31	832.0
13		18.7	4.42	1.58	111.9
14		20.1	16.00	1.70	405.2
15		22.2	192.26	1.87	4867.9
16		23.9	361.14	2.02	9143.9
17		34.4	0.24	2.91	6.2
18		37.3	0.23	3.15	6.0
19		39.1	1.53	3.30	38.9
20		41.9	1.34		
21		47.5	2.75	4.01	69.8
22		49.7	1.35	4.20	34.2
23	Pyridine region	63.8	24.28	5.40	614.9
24		66.5	55.27	5.62	1399.5
25		69.3	0.18	5.86	4.7
26		69.9	8.57	5.91	217.0
27		70.7	48.43	5.98	1226.3
28		84.5	3.55	7.14	89.9
29		92.9	0.17	7.86	4.3
30		93.7	0.21	7.92	5.4
31		94.6	0.31	8.00	7.9
32		97.4	0.15	8.23	4.0
33	3-Methylpyridine	194.7	258.44	16.47	6543.6
34	4-Methylpyridine	200.0	3283.24	16.92	83129.7
35		204.4	14.15	17.21	358.4
36		206.5	3.31	17.36	84.0
37		213.5	1.81		
38		216.1	0.36	18.01	9.2
39		219.1	16.46	18.22	416.9
40		220.4	14.13	18.30	357.9
41		225.2	0.93	18.63	23.7
42	Acetic acid	236.7	389.73	19.42	9867.7
43		240.1	71.15	19.64	1801.5
44		245.5	15.27	20.01	386.8
45	Formic acid	249.6	110.24	20.29	2791.2
46		257.4	0.36	20.82	9.1

TABLE E.5 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		261.5	10.45	21.10	264.5
48		269.0	0.64	21.61	16.4
49		274.5	4.20	21.99	106.5
50		277.0	2.22	22.15	56.3
51		279.9	2.52	22.35	64.0
52		282.7	46.96	22.54	1189.2
53		294.1	7.52	23.32	190.4
54		296.0	10.62	23.45	268.9
55	Pyridine	310.2	340.98	24.42	8633.4
56		321.0	1.17	25.15	29.6
57		326.7	1.03	25.54	26.1
58		334.1	32.83	26.04	831.4
59		338.0	6.30	26.31	159.7
60		342.6	22.37	26.62	566.5
61		347.6	11.19	26.96	283.4
62		355.3	1.81	27.48	45.9
63		360.7	8.38		
64		368.8	2.45	28.40	62.1
65		371.8	18.05	28.60	457.1
66		379.3	3.53	29.11	89.4
67		383.3	4.68	29.39	118.7
68		394.1	0.57	30.12	14.4
69		403.5	0.79	31.05	20.1
70		406.1	6.85	31.43	173.6
71		408.0	31.63	31.72	800.9
72		410.9	2.60	32.15	65.8
73		413.2	0.45	32.50	11.4
74		415.9	1.90	32.91	48.2
75		417.7	0.62	33.18	15.8
76		421.0	3.11	33.66	78.8
77		425.8	0.49	34.39	12.5
78		429.5	6.47	34.94	163.9

Total concentration: 5593.32 ppm

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Sample file: 72P575532.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.6 2-Methylpyridine Degradation: 625°F, 21 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.9	1.68	0.07	43.6
2		11.0	1.69	0.92	44.0
3		11.2	1.44		
4		11.9	4.49	1.00	116.4
5		12.2	15.76	1.02	408.5
6		14.0	13.88	1.17	359.9
7		15.0	35.92	1.25	931.4
8		18.1	7.82	1.52	202.7
9		20.2	35.76	1.69	927.2
10		22.3	11.27	1.87	292.3
11		23.7	26.70	1.98	692.1
12		26.5	41.48	2.22	1075.5
13		39.3	9.57	3.29	248.1
14		42.1	4.38	3.53	113.6
15		43.3	3.38	3.63	87.8
16		47.6	2.77	3.99	71.8
17		48.1	0.86	4.04	22.4
18		48.7	0.77	4.09	19.9
19		49.4	0.80	4.14	20.8
20		50.1	0.61	4.21	15.8
21		50.7	0.98	4.26	25.6
22	Pyridine region	58.5	0.90	4.91	23.4
23		59.5	0.19	4.99	5.0
24		60.1	0.25	5.05	6.6
25		60.7	0.19	5.10	4.9
26		61.8	0.22	5.19	5.9
27		64.3	24.90	5.40	645.6
28		67.0	42.67	5.63	1106.2
29		69.0	17.37		
30		70.7	15.03	5.93	389.6
31		71.2	6.89	5.98	178.8
32		71.8	7.21	6.03	187.0
33		72.8	83.72	6.11	2170.3
34		85.1	3.13	7.14	81.1
35		92.8	9.15	7.79	237.2
36		94.4	4.10	7.92	106.5
37		96.4	6.51	8.10	168.8
38		97.9	4.85	8.22	125.7
39		99.6	4.96	8.36	128.6
40		100.5	4.05	8.44	105.1
41	4-Methylpyridine	102.2	3.39	8.58	88.0
42		103.3	2.12	8.67	55.0
43		200.0	3334.84	16.80	86452.7
44		204.1	13.58	17.07	352.1
45		206.2	2.85	17.22	74.0
46		213.2	0.97		

TABLE E.6 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		218.9	1.12	18.07	29.1
48		220.2	7.85	18.16	203.5
49		225.3	0.40	18.50	10.4
50		230.4	7.59	18.85	196.9
51	Acetic acid	236.1	199.76	19.24	5178.8
52		245.6	5.27	19.88	136.7
53		248.5	1.96	20.07	50.9
54	Formic acid	249.4	76.06	20.14	1971.8
55		257.6	5.98		
56		261.9	3.09	20.98	80.2
57		274.7	0.98	21.84	25.5
58		284.3	21.65	22.49	561.3
59		295.1	15.83	23.22	410.5
60	C2-Pyridine	310.4	41.57	24.25	1077.8
61		323.2	3.20	25.11	83.1
62		334.0	14.84	25.85	384.9
63	N-Ethyl acetamide	345.2	3.97	26.60	103.0
64		349.4	17.37	26.88	450.5
65		357.1	0.28	27.40	7.4
66		362.7	0.16	27.78	4.1
67		370.5	0.19	28.31	5.1
68		374.0	3.76	28.54	97.5
69		381.8	0.84	29.07	21.8
70		385.5	0.97	29.32	25.1
71		388.5	0.27	29.52	7.1
72		396.5	0.14		
73		400.6	2.79	30.39	72.3
74		405.0	1.63	31.04	42.2
75		406.0	4.61	31.20	119.6
76	Acetamide	409.6	1.73	31.73	44.9
77		412.1	1.94	32.11	50.4
78		414.6	1.74	32.49	45.2
79		417.2	1.78	32.87	46.2
80		419.0	0.36	33.14	9.4
81		421.7	1.90	33.54	49.4
82		427.3	6.91	34.38	179.3
83		430.9	9.42	34.92	244.4

Total concentration: 4286.35 ppm

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Sample file: 76P625021.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.7 2-Methylpyridine Degradation: 625°F, 189 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.5	0.46	0.04	12.1
2		11.1	5.29	0.93	137.3
3		11.3	10.72	0.94	277.9
4		11.6	3.05	0.97	79.1
5		12.3	43.72	1.03	1133.6
6		12.9	12.87		
7		14.0	21.16	1.17	548.7
8		14.7	6.15	1.23	159.6
9		15.1	10.96	1.26	284.1
10		15.9	22.95	1.33	595.0
11		18.3	6.37	1.53	165.2
12		18.9	5.73	1.59	148.6
13		19.9	4.55	1.67	118.1
14		20.3	9.16	1.70	237.7
15		22.0	4.00		
16		22.4	11.51	1.88	298.5
17		23.8	38.58	2.00	1000.3
18		26.4	21.33	2.21	553.0
19		26.6	41.68	2.23	1080.5
20		34.9	2.01	2.93	52.2
21		38.1	2.48	3.19	64.4
22		39.3	5.68	3.30	147.4
23		42.1	1.93	3.53	50.1
24		43.7	6.38	3.67	165.5
25		47.8	2.54	4.01	65.9
26		50.0	1.46	4.19	37.9
27		51.3	1.04	4.31	27.0
28		53.1	1.72	4.46	44.6
29		55.4	0.81	4.65	21.1
30		58.5	0.21	4.91	5.6
31		59.0	0.13	4.96	3.5
32		60.5	0.24		
33	Pyridine region	62.1	0.11	5.21	3.0
34		64.4	23.08	5.41	598.3
35		67.1	53.06	5.63	1375.7
36		69.5	16.31	5.84	422.9
37		70.8	14.55	5.94	377.3
38		72.3	17.47	6.07	453.1
39		73.2	23.20	6.15	601.4
40		73.7	0.14	6.19	3.7
41		74.4	64.96	6.24	1684.2
42		85.0	2.72	7.14	70.6
43		97.7	19.28	8.21	500.0
44		98.6	1.95	8.28	50.6
45		99.6	8.12	8.37	210.5
46		102.5	5.27	8.61	136.6

TABLE E.7 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		104.1	2.14	8.75	55.5
48	4-Methylpyridine	200.0	3463.81	16.80	89796.0
49		203.9	11.13	17.07	288.7
50		206.1	4.44	17.21	115.1
51		210.1	0.15	17.49	3.9
52		213.0	1.54	17.68	39.9
53		218.7	8.43	18.07	218.6
54		219.9	15.59	18.15	404.2
55		225.0	3.06	18.50	79.4
56		230.4	0.17	18.87	4.5
57	Acetic acid	236.3	323.42	19.27	8384.3
58		239.7	70.76		
59		245.4	14.68	19.89	380.5
60	Formic acid	249.5	98.72	20.17	2559.4
61		257.1	0.33	20.69	8.5
62		261.6	8.35	20.99	216.6
63		268.8	0.54	21.48	14.1
64		275.0	7.04	21.90	182.6
65		283.3	54.53	22.47	1413.6
66		294.3	34.12	23.22	884.5
67	Pyridine	310.2	213.66	24.30	5538.9
68		322.1	2.57	25.11	66.7
69		326.6	0.24	25.41	6.3
70		333.5	37.83	25.88	980.8
71	N-Ethyl acetamide	343.4	17.09	26.55	443.0
72		348.4	26.72	26.89	692.7
73		355.7	3.95	27.39	102.4
74		361.1	11.38	27.76	295.0
75		372.6	25.16	28.54	652.4
76		380.1	4.35	29.05	112.9
77		384.0	7.92	29.32	205.5
78		394.9	3.23	30.06	83.7
79		404.0	1.30	31.00	33.7
80		406.5	8.93	31.37	231.7
81	Acetamide	408.3	16.23	31.64	420.9
82		411.3	2.46	32.10	63.7
83		413.5	7.38	32.43	191.4
84		416.3	6.68		

TABLE E.7 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
85		421.1	9.08	33.56	235.6
86		426.5	0.83	34.37	21.7
87		428.2	1.92	34.63	49.8
88		430.0	5.94	34.90	154.1
Total concentration: 5095.3 ppm					

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Sample file: 77P625189.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.8 2-Methylpyridine Degradation: 625°F, 359 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.6	1.91	0.04	49.6
2		10.9	9.57	0.91	248.3
3		11.2	22.37	0.94	580.1
4		12.2	49.98	1.02	1295.8
5		12.6	7.68	1.06	199.2
6		12.9	15.80	1.08	409.7
7		14.0	19.15	1.17	496.6
8		14.6	9.65	1.22	250.2
9		15.0	11.65	1.25	302.2
10		15.9	26.06	1.33	675.7
11		18.1	3.77	1.52	97.7
12		18.8	7.78	1.57	201.7
13		19.8	4.64	1.66	120.5
14		20.2	9.68		
15		22.3	17.22	1.86	446.4
16		23.6	44.44	1.98	1152.0
17		26.6	62.50	2.23	1620.3
18		34.6	6.10	2.90	158.3
19		38.1	4.57	3.19	118.5
20		39.0	5.17	3.27	134.0
21	Pyridine region	41.6	2.06	3.49	53.6
22		43.7	1.87	3.67	48.5
23		47.6	2.51	3.99	65.0
24		49.5	2.21	4.15	57.4
25		52.6	3.50	4.41	90.8
26		57.3	1.60	4.80	41.6
27		63.8	26.21	5.35	679.6
28		66.5	63.14	5.58	1637.1
29		70.6	14.61	5.93	378.7
30		72.1	16.77	6.05	434.9
31		73.1	20.34		
32		74.2	59.64	6.23	1546.3
33		84.4	3.39	7.09	88.0
34		94.1	1.95	7.90	50.5
35		98.2	0.39	8.24	10.2
36		98.7	0.17	8.28	4.5
37		99.3	0.33	8.34	8.7
38		101.8	0.83	8.55	21.5
39		102.9	0.59	8.64	15.3
40		197.2	3.39		
41	4-Methylpyridine	200.0	3433.64	16.79	89013.8
42		203.9	11.31	17.06	293.3
43		206.1	7.49	17.21	194.3
44		213.0	1.88	17.68	48.9
45		215.6	0.68	17.86	17.6
46		218.7	20.42	18.06	529.5

TABLE E.8 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		219.7	18.71	18.14	485.1
48		224.9	3.85	18.49	99.8
49		231.1	0.27	18.92	7.0
50	Acetic acid	236.3	350.98	19.27	9099.0
51		239.9	77.93	19.51	2020.4
52		245.2	17.70	19.88	458.9
53		247.2	1.93	20.01	50.2
54	Formic acid	249.4	87.98	20.16	2280.8
55		256.8	0.42	20.67	11.1
56		261.3	9.40	20.97	243.7
57	C2-Pyridine	266.4	0.98		
59		274.7	9.88	21.89	256.1
60		282.9	59.48	22.44	1542.1
61		294.3	37.75	23.22	978.8
62	C2-Pyridine	310.4	254.78	24.31	6605.1
63		321.6	2.22	25.08	57.8
64		327.1	0.40	25.45	10.6
65		333.9	33.86	25.92	877.9
66	Ethyl acetamide	343.4	23.75	26.56	615.8
67		348.2	24.09	26.89	624.5
68		355.9	5.72	27.41	148.3
69		361.3	10.85	27.78	281.5
70		364.2	6.37	27.98	165.2
71		372.6	30.43	28.55	788.9
72		379.8	6.57	29.05	170.4
73		383.8	9.31	29.32	241.3
74		394.5	7.35	30.04	190.6
75		403.7	1.22	30.97	31.8
76		406.4	9.41	31.37	244.1
77	Acetamide	408.1	19.14	31.64	496.4
78		413.1	4.17	32.39	108.1
79		416.1	2.29	32.83	59.4
80		417.9	0.65	33.09	16.8
81		420.9	10.50	33.55	272.2
82		426.1	0.84	34.33	21.8
83		427.9	1.50		
84		430.0	7.64	34.91	198.0

Total concentration: 5192.38 ppm

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.9 2-Methylpyridine Degradation: 625°F, 525 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.5	0.89	0.04	23.2
2		10.7	0.61	0.89	15.9
3		11.0	28.34	0.91	734.9
4		11.3	39.76	0.94	1030.8
5		12.3	110.57	1.02	2866.4
6		13.0	27.70	1.08	718.1
7		14.0	28.01	1.17	726.1
8		14.7	13.21	1.22	342.6
9		15.0	12.77	1.25	331.1
10		16.0	28.96	1.33	750.9
11		18.2	4.91	1.52	127.3
12		18.9	6.50	1.57	168.5
13		19.8	4.38	1.65	113.6
14		20.3	9.92	1.69	257.2
15		22.3	18.90	1.86	490.1
16		23.7	46.77	1.98	1212.5
17		26.6	69.01		
18	Pyridine region	34.7	9.77	2.89	253.3
19		37.9	7.93	3.16	205.7
20		38.9	7.91	3.25	205.1
21		41.6	5.46	3.47	141.7
22		47.3	1.46	3.95	38.0
23		47.9	0.77	4.00	20.1
24		49.6	2.93	4.14	76.1
25		52.8	3.68	4.41	95.4
26		57.2	2.76	4.77	71.6
27		63.9	27.09	5.34	702.5
28		66.6	79.36	5.56	2057.5
29		73.1	54.15	6.10	1403.8
30		73.8	0.17	6.16	4.6
31		74.5	57.90	6.22	1501.1
32		84.5	2.79	7.06	72.4
33		97.8	3.49	8.17	90.7
34		99.0	2.32	8.26	60.1
35	4-Methylpyridine	100.1	6.20	8.35	160.9
36		200.0	3438.45	16.70	89138.7
37		203.9	8.83	16.96	228.9
38		206.1	9.06	17.12	234.9
39		213.0	2.24	17.59	58.1
40	Acetic acid	215.9	0.47	17.79	12.3
41		218.7	49.69	17.98	1288.2
42		224.9	5.04	18.40	130.6
43		230.7	0.18		
44		236.5	360.19	19.19	9337.6
45		240.1	94.90	19.44	2460.3
46		245.4	23.26	19.80	603.1

TABLE E.9 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47	Formic acid	249.5	87.60	20.09	2271.1
48		257.0	0.45	20.59	11.8
49		261.5	10.51	20.90	272.5
50	C2-Pyridine	266.7	1.40	21.26	36.5
51		268.5	1.25	21.38	32.5
52		274.9	11.70	21.82	303.4
53		283.2	56.39	22.38	1461.9
54		290.4	0.18	22.88	4.7
55		294.3	38.35	23.14	994.4
56	C2-Pyridine	310.6	272.60	24.26	7067.0
57		321.6	2.19	25.01	56.9
58		327.6	0.61	25.42	15.8
59		334.5	26.24	25.89	680.4
60		338.4	4.52	26.15	117.3
61		343.4	29.00	26.50	751.8
62	N-Ethyl acetamide	348.4	9.45	26.84	245.1
63		351.1	8.85	27.03	229.4
64		356.1	6.02	27.37	156.2
65		361.4	14.09	27.73	365.4
66		364.6	7.74	27.94	200.8
67		372.8	32.04	28.50	830.7
68		380.1	7.69	29.01	199.3
69		384.0	9.00		
70		394.7	8.47	30.00	219.8
71		403.7	2.73	30.91	70.8
72		406.4	13.44	31.33	348.6
73		408.2	29.91	31.60	775.6
74	Acetamide	411.2	3.28	32.03	85.2
75		413.2	10.43	32.33	270.5
76		416.1	2.27	32.77	58.9
77		418.1	1.33	33.07	34.6
78		421.1	10.09	33.52	261.8
79		426.0	0.71	34.26	18.5
80		427.7	1.12	34.51	29.1
81		429.6	3.40	34.80	88.3

Total concentration: 5445.13 ppm

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.10 2-Methylpyridine Degradation: 625°F, 694 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.2	1.23	0.01	33.4
2		10.6	1.04	0.88	28.4
3		10.9	22.30	0.91	605.6
4		11.0	12.65	0.92	343.5
5		11.2	35.75	0.93	970.9
6		11.5	14.44	0.95	392.3
7		11.9	63.74	0.99	1730.7
8		12.2	42.66	1.01	1158.4
9		12.6	11.06	1.05	300.2
10		12.9	29.24	1.07	793.9
11		13.8	28.09	1.15	762.8
12		14.6	10.30	1.22	279.7
13		14.9	14.54	1.24	395.0
14		15.8	32.93	1.32	894.1
15		18.1	4.16	1.51	113.0
16		18.8	6.36	1.56	172.7
17		19.7	5.20	1.64	141.2
18		20.1	10.88	1.68	295.5
19		21.8	3.91	1.82	106.3
20		22.2	9.04	1.85	245.5
21	Pyridine region	23.6	34.42	1.97	934.7
22		26.4	47.77	2.21	1297.0
23		31.0	0.16		
24		34.5	9.71	2.88	263.7
25		37.5	9.38	3.14	254.8
26		38.6	6.45	3.23	175.3
27		41.4	2.55	3.46	69.4
28		46.7	0.14	3.90	3.8
29		48.1	0.18	4.02	5.1
30		49.5	0.59	4.14	16.0
31		50.7	0.30	4.24	8.3
32		52.5	1.89	4.39	51.4
33		54.5	1.07	4.55	29.2
34		56.9	1.83	4.75	49.7
35		64.0	24.70	5.35	670.8
36		66.5	85.12	5.56	2311.3
37	4-Methylpyridine	72.6	99.18	6.07	2692.9
38		84.3	3.48	7.05	94.5
39		89.6	2.61	7.49	71.0
40		93.3	5.16	7.80	140.1
41		95.4	4.04	7.98	109.7
42		98.6	7.20	8.24	195.5
43		100.1	5.69	8.37	154.5
44		101.9	7.70	8.52	209.2
45		200.0	3483.06	16.72	94570.8
46		203.8	9.57	16.98	259.9

TABLE E.10 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		206.0	11.00	17.13	298.7
48		212.9	1.90	17.60	51.6
49		218.6	54.82		
50		224.7	4.90	18.40	133.1
51	Acetic acid	236.1	327.15	19.18	8882.7
52		239.8	120.45	19.43	3270.4
53		245.0	33.16	19.79	900.3
54		248.3	8.45	20.01	229.4
55	Formic acid	249.6	64.62	20.10	1754.5
56		256.7	8.57	20.58	232.7
57		261.0	11.01	20.87	299.1
58	Pyridine	266.0	3.15	21.21	85.6
59		274.3	11.87	21.78	322.4
60		282.5	54.19	22.34	1471.4
61		293.8	37.24	23.10	1011.3
62	C2-Pyridine	310.2	266.60	24.22	7238.7
63		321.0	1.54	24.95	41.9
64		327.2	0.64	25.37	17.6
65		334.3	26.78	25.86	727.2
66	N-Ethyl acetamide	343.1	35.65		
67		351.1	9.97	27.00	270.7
68		356.0	5.85	27.33	158.8
69		361.4	13.80	27.70	374.8
70		364.0	9.36	27.88	254.2
71		372.7	31.23	28.47	848.1
72		380.0	9.16	28.97	248.9
73		383.8	8.72	29.23	236.9
74		394.7	8.62	29.97	234.2
75		403.6	2.33		
76		406.5	11.69	31.30	317.4
77	Acetamide	408.3	37.44	31.57	1016.5
78		413.2	11.52	32.30	312.9
79		416.0	1.75	32.72	47.7
80		418.2	1.27	33.05	34.5
81		421.1	9.17	33.49	249.2
82		426.2	0.39	34.25	10.6
83		427.7	1.52	34.47	41.4
84		429.8	3.89	34.79	105.6

Total concentration: 5475.19 ppm

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.11 2-Methylpyridine Degradation: 625°F, 837 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.5	2.70	0.04	73.5
2		10.6	1.02	0.88	27.7
3		10.9	27.61	0.91	749.7
4		11.0	16.64	0.91	451.9
5		11.2	44.32	0.93	1203.4
6		11.9	61.76	1.00	1677.0
7		12.1	32.25	1.01	875.8
8		12.3	16.82	1.03	456.8
9		12.6	14.70		
10		12.8	31.87	1.07	865.4
11		13.8	35.08	1.15	952.6
12		14.5	13.43	1.21	364.8
13		14.9	14.61	1.24	396.7
14		15.8	33.35	1.32	905.7
15		18.0	3.77	1.50	102.4
16		18.7	6.04	1.56	164.2
17		19.7	4.59	1.64	124.8
18		20.1	10.29	1.68	279.4
19		22.1	16.97	1.85	460.8
20	Pyridine region	23.5	45.82	1.96	1244.3
21		26.5	55.70	2.21	1512.4
22		30.9	5.49	2.58	149.2
23		34.4	15.94	2.88	432.8
24		37.7	10.04	3.15	272.7
25		38.5	11.42	3.22	310.1
26		41.1	1.29		
27		49.3	1.85	4.12	50.4
28		52.6	2.92	4.40	79.3
29		54.8	0.41	4.59	11.2
30		55.4	0.50	4.64	13.6
31		56.6	0.61	4.74	16.5
32		57.7	1.38	4.83	37.6
33		63.5	24.81	5.31	673.7
34		66.1	71.59	5.53	1944.0
35		69.9	0.11		
36		72.7	32.51	6.08	882.7
37		73.7	63.33	6.17	1719.7
38	4-Methylpyridine	84.0	2.56	7.03	69.6
39		91.2	2.36	7.63	64.1
40		95.6	4.92	8.01	133.6
41		97.9	4.08	8.20	110.9
42		98.9	12.39	8.28	336.5
43		200.0	3497.33	16.75	94958.3
44		203.8	8.28	17.01	224.8
45		206.0	12.60	17.16	342.3
46		212.8	2.02	17.62	55.0

TABLE E.11 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		218.7	66.14	18.02	1795.8
48		224.7	4.99	18.43	135.6
49	Acetic acid	236.3	357.03	19.23	9694.1
50		239.9	122.43	19.47	3324.3
51		245.2	29.27	19.83	794.8
52		248.5	9.02		
53	Formic acid	249.5	79.87	20.13	2168.6
54		256.9	0.55	20.62	15.1
55		261.3	11.98	20.93	325.3
56	C2-Pyridine	266.4	3.64	21.27	99.0
57		274.8	14.47	21.85	393.0
58		283.0	53.72	22.41	1458.8
59		294.2	41.72	23.17	1132.8
60	C2-Pyridine	310.4	280.03	24.28	7603.4
61		321.2	2.28	25.01	61.9
62		327.2	0.89	25.42	24.3
63		334.4	28.39	25.91	771.0
64	N-Ethyl acetamide	343.1	38.96	26.51	1057.9
65		351.1	10.72	27.05	291.1
66		355.9	6.46	27.38	175.5
67		361.2	16.44	27.74	446.5
68		364.0	11.34	27.93	308.1
69		372.5	33.46	28.51	908.7
71		383.4	8.40	29.25	228.2
72		394.4	10.10	30.01	274.2
73		403.4	3.09	30.90	84.0
74		406.3	13.96	31.33	379.2
75	Acetamide	408.2	43.44	31.61	1179.6
76		411.2	0.14	32.06	3.9
77		413.1	14.45	32.34	392.5
78		415.4	2.28		
79		417.9	2.54	33.07	69.1
80		421.1	13.31	33.54	361.4
81		426.0	0.88	34.27	24.0
82		427.4	3.01	34.49	81.8
83		429.5	4.85	34.80	131.7

Total concentration: 5637.48 ppm

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.12 2-Methylpyridine Degradation: 625°F, 1153 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	0.5	0.73	0.04	19.9
2		10.6	0.62	0.88	17.0
3		10.8	45.84	0.90	1244.6
4		11.1	47.21	0.93	1281.8
5		11.4	16.47	0.95	447.3
6		11.8	129.84	0.98	3525.4
7		12.5	14.31	1.05	388.5
8		12.8	36.77	1.07	998.5
9		13.1	0.12	1.09	3.3
10		13.8	38.29	1.15	1039.7
11		14.5	8.38	1.21	227.5
12		14.9	18.78	1.24	510.1
13		15.8	50.19		
14		17.9	0.13	1.50	3.5
15		18.7	8.55	1.56	232.3
16		20.1	26.94	1.68	731.5
17		22.0	22.59	1.84	613.4
18		23.4	45.93	1.96	1247.1
19		26.3	55.55	2.20	1508.5
20	Pyridine region	30.9	6.27	2.58	170.4
21		34.4	24.25	2.87	658.6
22		37.3	41.23	3.12	1119.4
23		41.0	0.11	3.43	3.0
24		49.4	1.25	4.13	34.2
25		52.4	2.74	4.39	74.4
26		54.3	0.56	4.55	15.4
27		55.6	1.04	4.65	28.3
28		56.2	0.79	4.71	21.6
29		57.2	1.23	4.78	33.5
30		59.4	0.28	4.97	7.7
31		63.6	20.21	5.32	548.7
32		66.4	70.84	5.56	1923.4
33		71.7	32.39	6.00	879.6
34		72.6	13.22	6.07	359.1
35		73.7	59.25	6.17	1608.9
36		83.8	2.55	7.02	69.4
37		89.2	2.27	7.46	61.7
38		90.8	1.18	7.60	32.3
39		91.9	1.30		
40		94.3	3.55	7.89	96.4
41		95.8	2.74	8.02	74.6
42		98.5	7.46	8.25	202.6
43		99.6	7.89	8.34	214.4
44		102.7	2.32	8.60	63.0
45	4-Methylpyridine	200.0	3581.67	16.74	97248.4
46		203.8	7.95	17.00	215.9

TABLE E.12 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		206.0	17.11	17.16	464.6
48		212.8	2.47	17.62	67.2
49		218.7	89.64	18.01	2433.9
50		224.7	8.00	18.42	217.4
51	Acetic acid	236.3	353.26	19.22	9591.7
52		240.1	162.49	19.47	4411.8
53		245.2	34.92	19.82	948.2
54		248.4	10.97	20.04	298.0
55	Formic acid	249.7	78.11	20.13	2121.0
56		256.6	0.35		
57		261.2	13.69	20.91	371.7
58	C2-Pyridine	266.3	4.76	21.25	129.4
59		274.5	15.39	21.81	417.9
60		282.8	47.04	22.37	1277.3
61		294.0	36.85	23.13	1000.8
62	C2-Pyridine	310.2	244.37	24.23	6635.1
63		320.7	12.64	24.95	343.2
64		326.9	6.55	25.37	177.8
65		330.7	3.67		
66		334.4	24.37	25.88	661.8
67	N-Ethyl acetamide	343.0	38.65	26.47	1049.4
68		351.1	12.99	27.02	352.9
69		355.8	6.35	27.34	172.5
70		361.3	18.33	27.71	497.6
71		363.5	2.26	27.86	61.5
72		364.0	11.32	27.89	307.4
73		372.4	35.70	28.47	969.5
74		380.2	24.18	28.99	656.6
75		394.5	11.12	29.97	302.1
76		403.3	1.24	30.84	33.8
77		406.4	11.12	31.30	302.0
78	Acetamide	408.2	42.01	31.57	1140.8
79		413.0	10.69	32.29	290.3
80		418.0	0.92	33.03	25.1
81		421.2	9.89	33.51	268.7
82		427.5	2.24		
83		429.8	2.81	34.79	76.3

Total concentration: 5872.65 ppm

RI/CONC REPORT

Sample file: 84P6251153.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.13 2-Methylpyridine Degradation: 675°F, Initial Material

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	12.3	1.48	1.02	40.3
2		15.2	8.30	1.26	225.5
3		20.2	1.19	1.67	32.4
4		22.2	5.78	1.84	157.0
5		23.6	47.86	1.96	1299.7
6		25.8	69.67	2.14	1891.6
7		33.2	9415.72	2.75	
8		44.4	12729.90	3.68	345638.6
9		56.8	239.66	4.71	6507.3
10	Pyridine region	64.3	114.14	5.34	3099.1
11		67.0	480.40	5.56	13043.7
12		84.8	443.62	7.03	12045.3
13	4-Methylpyridine	200.0	2290.89	16.60	62201.4
14		221.8	1.86	18.11	50.5
15	Acetic acid	237.2	64.64	19.19	1755.2
16		253.2	14.42	20.30	391.6
17	N-Ethyl acetamide	335.7	0.20	26.03	5.6
18		342.9	0.35	26.53	9.6
19		403.3	14.63	31.00	397.2
20	Acetamide	408.0	0.17	31.70	4.6
21		424.9	0.30	34.23	8.1
Total concentration: 25945.3 ppm					

RI/CONC REPORT

Sample file: 85P675000.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.14 2-Methylpyridine Degradation: 675°F, 22 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.0	16.18	0.92	478.1
2		11.8	6.33	0.99	187.2
3		12.2	44.96	1.02	1328.5
4		14.8	37.31		
5		22.0	6.48	1.85	191.6
6		23.4	33.36	1.96	985.9
7		25.4	33.91	2.14	1001.9
8		31.3	3083.46	2.63	91101.8
9		41.5	2779.43	3.49	82119.3
10	Pyridine region	63.4	18.36	5.34	542.5
11		66.2	149.98	5.57	4431.3
12		83.7	3.70	7.04	109.4
13		93.3	14.75	7.86	435.8
14	4-Methylpyridine	200.0	2876.17	16.85	84977.5
15		214.6	151.99	17.84	4490.5
16		221.1	16.25	18.28	480.3
17		225.1	2.97	18.55	88.0
18		227.6	0.66	18.72	19.6
19		230.2	4.32	18.89	127.8
20		234.0	39.05	19.15	1153.9
21		237.5	858.04		
22		245.5	649.26	19.93	19182.7
23		250.6	874.24	20.28	25829.8
24		254.9	159.88	20.56	4723.9
25		264.3	12.60	21.20	372.5
26	C2-Pyridine	275.6	0.75	21.97	22.4
27		281.3	6.61	22.35	195.4
28		283.1	12.17	22.47	359.7
29		295.3	2.02	23.30	59.7
30		297.8	3.43		
31		309.8	59.22	24.29	1749.7
32		325.9	0.28	25.37	8.4
33		333.9	6.66	25.92	196.8
34		342.4	16.80	26.49	496.5
35		354.7	0.19	27.33	5.8
36	N-Ethyl acetamide	362.5	0.28	27.85	8.5
37		371.8	22.16	28.48	654.9
38		382.9	2.96	29.23	87.5
39		393.2	2.54	29.93	75.2

TABLE E.14 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
40	Acetamide	409.7	434.80	31.85	12846.5
41		412.5	0.35	32.27	10.4
42		416.2	0.26	32.82	7.7
43		420.6	2.53	33.47	74.8
44		426.3	2.78	34.33	82.2
45		428.0	2.44	34.58	72.1
Total concentration: 12453.1 ppm					

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Sample file: 88bP675022.001

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.15 2-Methylpyridine Degradation: 675°F, 191 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.0	105.75	0.92	3124.4
2		11.8	88.06	0.99	2601.8
3		12.8	35.05	1.07	1035.6
4		14.9	87.29	1.25	2579.2
5		21.9	55.86	1.84	1650.5
6		23.4	77.17	1.96	2280.3
7		31.0	1011.19	2.60	29876.0
8		40.9	1049.77	3.44	31015.7
9	Pyridine region	63.3	18.42	5.32	544.4
10		65.5	133.81	5.51	3953.7
11		83.4	2.46	7.01	72.8
12		93.5	11.59	7.86	342.5
13	4-Methylpyridine	200.0	939.15	16.82	27747.6
14		204.3	138.80	17.11	4101.0
15		208.9	14.83	17.42	438.1
16		214.5	1932.65	17.81	57100.7
17		229.0	120.78	18.80	3568.6
18		230.2	53.32	18.89	1575.4
19		232.4	2039.71		
20		237.9	987.14	19.41	29165.6
21	C2-Pyridine	243.1	713.95	19.77	21094.1
22		248.7	827.09	20.15	24436.9
23		253.3	905.54	20.46	26754.5
24		257.6	188.54	20.76	5570.7
25		266.5	42.04	21.37	1242.2
26		277.4	8.06	22.11	238.1
27		285.0	13.78	22.63	407.3
28		296.7	5.74	23.43	169.6
29	C2-Pyridine	302.2	4.66	23.81	137.7
30		310.7	111.74	24.40	3301.6
31		326.1	0.13	25.45	4.0
32		334.4	17.11	26.01	505.6
33	N-Ethyl acetamide	343.1	51.89	26.61	1533.3
34		349.7	5.55	27.06	164.1
35		355.4	3.87	27.45	114.3
36		360.0	2.42		
37		363.5	2.49	28.01	73.5
38		371.5	18.10	28.56	534.8
39		378.0	1.28	29.00	37.8
40		382.4	2.49	29.30	73.6
41		392.6	2.00	30.00	59.2

TABLE E.15 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
42	Acetamide	408.9	392.81	31.84	11605.8
43		412.5	2.92	32.38	86.4
44		416.6	0.71	32.98	21.1
45		420.3	10.37		
46		426.1	5.82	34.41	172.0
Total concentration:		12244.1 ppm			

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Sample file: 89P675191.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.16 2-Methylpyridine Degradation: 675°F, 359 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.0	2.18	0.91	64.4
2		12.4	1.51	1.02	44.8
3		15.0	14.36	1.24	424.4
4		15.5	80.10	1.29	2366.6
5		21.1	64.79	1.75	1914.2
6		22.2	33.00	1.84	975.2
7		23.6	56.65		
8		31.1	471.01	2.58	13916.2
9		42.0	633.27	3.48	18710.4
10	Pyridine region	63.7	8.15	5.29	240.8
11		66.4	49.16	5.51	1452.6
12		84.2	1.32	6.99	39.0
13		93.1	7.53	7.72	222.5
14	4-Methylpyridine	200.0	854.92	16.60	25259.2
15		203.3	164.39	16.83	4857.0
16		208.4	27.83	17.19	822.5
17		213.7	1860.66	17.56	54973.9
18		230.6	0.41	18.73	12.3
19		234.6	1960.16	19.01	57913.6
20		238.4	908.07	19.27	26829.5
21		240.1	767.33	19.39	22671.2
22		242.3	1067.54	19.54	31541.0
23		247.7	727.94	19.92	21507.3
24		252.6	827.07	20.26	24436.1
25		254.8	299.87	20.41	8859.8
26		256.2	642.68	20.51	18988.5
27		260.7	192.48	20.82	5686.9
28		269.1	63.36	21.41	1872.2
29		279.3	15.21	22.11	449.6
30		286.7	14.92	22.63	441.0
31	C2-Pyridine	299.6	7.57	23.53	223.7
32		304.8	3.84	23.89	113.6
33		312.1	126.59		
34		331.8	1.47	25.77	43.6
35		335.8	20.98	26.04	619.9
36	N-Ethyl acetamide	344.6	71.63	26.65	2116.5
37		351.2	11.23	27.11	332.0
38		356.2	9.22	27.46	272.5
39		360.5	5.48	27.76	162.0
40		364.3	7.64	28.03	225.9
41		371.9	19.78	28.55	584.6
42		378.4	3.02	29.01	89.3
43		382.8	3.71	29.31	109.8
44		385.3	3.94	29.49	116.4
45		392.5	5.89	29.99	174.1

TABLE E.16 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
46	Acetamide	410.2	572.36	32.03	16910.8
47		416.5	1.54	32.97	45.7
48		420.2	17.36	33.53	513.1
49		426.2	6.44	34.42	190.5
Total concentration: 12717.8 ppm					

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Sample file: 90P675359.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.17 2-Methylpyridine Degradation: 675°F, 514 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.0	2.72		
2		12.4	3.80	1.02	112.4
3		15.1	98.38	1.24	2906.6
4		20.9	75.99	1.73	2245.2
5		22.2	27.22	1.84	804.2
6		23.7	70.69	1.96	2088.7
7		31.3	414.72	2.58	12253.3
8		41.6	541.14	3.44	15988.4
9	Pyridine region	64.1	11.62	5.30	343.3
10		67.0	93.20		
11		84.8	1.95	7.02	57.7
12	4-Methylpyridine	95.0	10.21	7.86	301.6
13		200.0	1197.01	16.56	35366.1
14		204.4	158.88	16.86	4694.1
15		209.2	29.38	17.20	868.2
16		213.5	1943.29	17.49	57415.3
17		231.3	53.13	18.73	1570.0
18		233.6	993.34	18.89	29348.6
19		235.8	1594.58	19.04	47112.5
20		240.0	984.06	19.33	29074.7
21		245.4	616.83	19.70	18224.6
22		250.3	864.94	20.05	25555.1
23		254.5	884.01	20.34	26118.5
24	C2-Pyridine	259.0	210.13	20.65	6208.6
25		268.0	77.55	21.27	2291.3
26		278.7	18.33	22.01	541.5
27		286.2	13.15		
28	C2-Pyridine	299.2	7.35	23.43	217.3
29		303.9	4.95	23.76	146.4
30		311.9	130.20	24.32	3846.9
31		328.1	1.70	25.44	50.4
32	N-Ethyl acetamide	331.6	3.07	25.68	90.7
33		335.5	23.63	25.95	698.1
34		345.0	77.63	26.61	2293.8
35		351.5	16.46	27.07	486.4
36		356.6	12.14	27.42	358.7
37		360.8	6.65	27.71	196.5
38		364.9	9.17	27.99	270.9
39		372.1	18.55	28.50	548.0
40		378.8	3.04	28.96	89.9
41		383.2	2.97	29.26	87.9
42		386.1	4.38	29.47	129.5
43		393.1	6.01	29.95	177.6

TABLE E.17 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
44	Acetamide	409.9	501.76	31.91	14824.8
45		416.9	0.26	32.96	7.8
46		420.6	17.19	33.51	507.9
47		426.5	5.36	34.39	158.6
48		430.5	1.05	34.99	31.1
Total concentration:		11844.0 ppm			

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Sample file: 91P675514.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.18 2-Methylpyridine Degradation: 675°F, 532 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	10.7	1.35	0.88	40.3
2		11.0	57.00	0.90	1695.6
3		11.3	29.93	0.93	890.4
4		12.0	121.00	0.99	3599.3
5		13.0	61.49		
6		15.1	122.03	1.24	3629.7
7		21.1	87.33	1.74	2597.6
8		22.2	40.86	1.83	1215.3
9		23.6	71.71	1.95	2133.2
10		26.1	59.24	2.16	1762.2
11		31.1	348.64	2.57	10370.1
12		41.6	567.39	3.44	16876.8
13	Pyridine region	63.4	22.23	5.25	661.4
14		66.1	147.36	5.47	4383.1
15		84.0	2.99	6.95	88.9
16		93.8	6.20	7.77	184.4
17	4-Methylpyridine	200.0	984.96	16.57	29297.3
18		203.7	200.96	16.82	5977.6
19		208.7	37.71	17.17	1121.7
20		213.5	1850.82	17.50	55051.5
21		227.5	71.65	18.47	2131.3
22		233.8	1495.61		
23		237.0	1513.48	19.13	45017.6
24		241.0	1007.77	19.40	29975.5
25		246.2	617.96	19.77	18381.0
26		251.2	851.35	20.11	25322.9
27		255.0	873.32	20.37	25976.4
28		259.5	214.87	20.68	6391.2
29	C2-Pyridine	268.4	80.62	21.30	2398.0
30		278.7	19.32	22.01	574.8
31		286.3	12.16	22.54	361.7
32		299.1	7.31	23.43	217.6
33		303.5	5.25	23.73	156.1
34		311.7	130.47	24.30	3880.8
35		327.9	1.68	25.42	50.0
36		331.3	3.16	25.65	94.0
37		335.4	24.40	25.94	726.0
38	N-Ethyl acetamide	344.9	79.44	26.60	2362.9
39		351.4	15.25	27.04	453.8
40		356.4	12.90	27.39	383.8
41		360.6	6.14	27.68	182.8
42		364.8	10.15	27.97	301.9
43		372.1	18.49	28.48	550.0
44		378.5	3.08	28.92	91.7
45		383.1	2.78	29.24	82.8
46		386.2	4.76	29.45	141.7

TABLE E.18 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47	Acetamide	392.8	5.80	29.91	172.6
48		410.2	541.78		
49		416.9	2.25	32.93	66.9
50		420.5	20.07	33.48	596.9
51		426.4	5.83	34.37	173.5
52		430.2	2.24	34.93	66.7
Total concentration:		12482.7 ppm			

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Sample file: 94P675532.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.19 2-Methylpyridine Degradation: 675°F, 678 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	10.7	2.21	0.88	65.8
2		10.9	68.27	0.90	2030.7
3		11.3	34.14	0.93	1015.5
4		12.0	158.10	0.99	4702.6
5		12.9	69.45	1.07	2065.9
6		15.1	165.48	1.24	4922.3
7		21.1	120.50	1.75	3584.2
8		22.1	46.29	1.83	1376.9
9		23.6	79.73	1.95	2371.6
10		26.1	71.22	2.16	2118.6
11		30.8	304.19	2.55	9048.0
12		41.4	476.85	3.43	14183.6
13		63.4	23.43		
14	Pyridine region	66.0	63.03	5.47	1874.9
15		71.2	107.33	5.90	3192.5
16		83.7	2.98	6.95	88.9
17		96.4	11.41	8.00	339.5
18	4-Methylpyridine	200.0	1483.75	16.59	44133.4
19		205.3	157.40	16.96	4681.8
20		210.0	34.96	17.28	1039.9
21		214.2	1968.30	17.57	58545.8
22		229.5	0.36	18.63	10.7
23		233.3	1408.39	18.90	41891.7
24		236.3	1475.79	19.10	43896.6
25		240.2	1004.78	19.37	29886.5
26		245.4	614.51	19.73	18278.2
27		250.3	854.96	20.07	25430.4
28		254.3	952.26	20.35	28324.6
29		258.9	219.36	20.67	6524.7
30	C2-Pyridine	267.8	95.16	21.28	2830.6
31		278.3	23.19	22.00	689.9
32		286.0	12.89	22.54	383.6
33		298.8	8.17	23.42	243.2
34	C2-Pyridine	303.2	5.39	23.73	160.4
35		311.6	138.17	24.31	4109.9
36		328.0	2.47	25.44	73.7
37		331.0	4.12	25.65	122.5
38	N-Ethyl acetamide	335.0	27.31	25.92	812.4
39		344.6	86.98		
40		351.2	18.94	27.04	563.5
41		356.3	15.95	27.39	474.6
42		360.6	10.49	27.69	312.2
43		364.7	11.67	27.97	347.3
44		371.9	18.39	28.47	547.0
45		378.4	3.32	28.92	98.8
46		382.6	2.90	29.21	86.4

TABLE E.19 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		385.9	4.66	29.44	138.6
48		392.9	7.07	29.92	210.3
49	Acetamide	409.7	468.48	31.86	13934.9
50		416.8	1.02	32.93	30.3
51		420.4	20.65	33.47	614.2
52		426.3	2.34	34.35	69.7
53		430.2	1.62	34.94	48.2
Total concentration: 12971.0 ppm					

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Sample file: 95P675678.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.20 2-Methylpyridine Degradation: 675°F, 850 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.0	19.45	0.91	578.5
2		11.3	8.49	0.94	252.7
3		12.1	36.39		
4		12.7	5.17	1.06	153.8
5		13.0	13.06	1.08	388.5
6		14.0	13.74	1.16	408.7
7		15.1	155.23	1.25	4617.3
8		21.2	114.88	1.76	3417.1
9		22.2	46.21	1.84	1374.7
10		23.6	122.05	1.96	3630.3
11	Pyridine Region	30.7	254.35	2.55	7565.5
12		41.7	390.88	3.47	11626.6
13		63.2	17.92	5.25	533.2
14		65.8	53.03	5.48	1577.5
15		71.0	70.43	5.91	2095.1
16		83.7	2.63	6.96	78.5
17		95.8	9.31	7.97	276.9
18	4-Methylpyridine	200.0	1666.81	16.64	49578.3
19		206.5	121.03	17.09	3600.2
20		211.1	33.56	17.40	998.2
21		215.4	1907.92	17.71	56749.9
22		229.2	29.93	18.66	890.4
23		230.9	14.33	18.77	426.2
24		233.1	3044.65	18.92	90561.2
25		240.3	981.50	19.42	29194.3
26		245.4	623.86	19.77	18556.4
27		250.6	917.95	20.13	27304.0
28	C2-Pyridine	253.3	219.99	20.32	6543.5
29		254.5	676.62		
30		259.1	208.84	20.72	6212.0
31		268.0	98.16	21.34	2919.7
32		278.6	24.04	22.07	715.2
33		286.0	10.04	22.59	298.9
34		298.7	8.51	23.46	253.1
35		303.6	5.42	23.80	161.4
36		311.6	133.53	24.35	3971.8
37		327.7	2.97	25.46	88.3
38	N-Ethyl acetamide	330.9	4.77	25.69	141.9
39		335.0	29.98	25.97	891.8
40		344.5	94.47	26.62	2810.1
41		351.2	20.80	27.09	618.7
42		356.2	18.03	27.43	536.5
43		360.4	7.42	27.72	220.9
44		364.4	12.66	28.00	376.8
45		371.5	17.19	28.49	511.3
46		378.4	3.17		

TABLE E.20 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47		382.5	2.76	29.25	82.2
48		385.7	4.60	29.47	137.0
49		392.7	7.70	29.95	229.2
50	Acetamide	409.4	486.79	31.87	14479.5
51		412.5	6.34	32.33	188.8
52		416.9	2.41	32.98	71.6
53		420.3	26.54	33.50	789.5
54		426.2	3.73	34.38	111.0
Total concentration: 12812.5 ppm					

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Sample file: 96P675850.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.21 2-Methylpyridine Degradation: 675°F, 921 h Sample

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.0	4.07	0.90	121.1
2		12.8	1.41	1.05	42.1
3		13.0	1.48	1.07	44.0
4		14.1	3.16	1.16	94.2
5		15.1	163.58	1.24	4865.8
6		21.1	139.24	1.73	4141.8
7		22.3	96.98	1.83	2884.6
8		23.8	199.24	1.96	5926.3
9		31.1	232.65	2.56	6920.1
10		41.3	357.14	3.41	10622.9
12		66.4	123.57	5.48	3675.7
13		84.4	4.24	6.96	126.2
14		92.0	13.66	7.59	406.3
15	4-Methylpyridine	200.0	1173.69	16.51	34910.8
16		206.4	88.24	16.96	2624.6
17		212.4	1849.92	17.37	55024.8
18		236.0	23.77		
19		240.2	3377.29	19.33	100455.5
20		243.8	680.57	19.58	20243.1
21		245.4	1870.09	19.69	55624.7
22		252.5	620.92	20.19	18469.0
23		256.6	610.58	20.48	18161.4
24		260.4	987.28	20.74	29366.1
25		263.6	220.48	20.97	6558.0
26		271.6	105.85	21.52	3148.6
27		280.4	21.49	22.14	639.2
28		284.1	8.25	22.40	245.5
29	C2-Pyridine	287.8	12.69	22.66	377.6
30		294.0	1.60	23.09	47.6
31		300.6	8.55	23.56	254.5
32		306.6	4.22	23.98	125.6
33		312.9	117.40	24.42	3492.1
34		328.7	3.97	25.53	118.3
35		331.8	5.03	25.75	149.7
36		335.8	27.37	26.03	814.3
37	N-Ethyl acetamide	345.1	82.98	26.68	2468.3
38		351.3	21.10	27.11	627.8
39		356.3	15.27	27.46	454.2
40		360.3	7.74	27.75	230.3
41		364.7	11.66	28.05	347.0
42		371.4	13.78	28.53	410.0
43		377.8	2.77	28.97	82.6
44		385.0	6.24		
45	Acetamide	392.3	6.28	29.99	186.7
46		409.8	574.36	31.99	17084.0
47		416.1	2.49	32.93	74.1

TABLE E.21 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
48		420.0	21.92	33.52	652.2
49		425.8	2.51	34.39	74.7
Total concentration: 13949.7 ppm					

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Sample file: 97P675921.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.22 2-Methylpyridine Degradation: 675°F, 993 h

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.0	4.37	0.92	130.0
2		11.5	3.18	0.96	94.8
3		12.3	7.70	1.02	229.1
4		13.0	6.24	1.08	185.8
5		15.0	62.14	1.25	1848.3
6		15.4	324.06	1.29	9638.9
7		22.1	442.53	1.84	13162.9
8		23.9	337.67	2.00	10044.0
9		30.9	292.67	2.58	8705.5
10		42.1	352.38	3.52	10481.6
11		63.0	15.34	5.27	456.4
12	Pyridine region	65.5	42.39		
13		70.3	60.76	5.88	1807.4
14		83.3	2.43	6.97	72.3
15		96.4	7.95	8.07	236.5
16	4-Methylpyridine	200.0	2061.60	16.73	61320.9
17		206.7	172.78	17.19	5139.4
18		211.2	52.18	17.50	1552.1
19		215.8	1962.54	17.82	58374.6
20		228.6	60.51	18.70	1799.9
21		232.6	3189.24	18.97	94861.9
22		239.8	1012.48	19.47	30115.5
23		245.0	620.91	19.82	18468.8
24		250.0	1203.70	20.16	35803.3
25		253.7	627.88	20.42	18676.2
26		258.4	222.71	20.74	6624.5
27	C2-Pyridine	267.4	112.82	21.36	3355.7
28		277.9	27.52	22.08	818.8
29		285.5	8.76	22.60	260.5
30		292.3	1.10	23.07	32.9
31	C2-Pyridine	296.6	8.80	23.36	262.0
32		303.1	5.52	23.80	164.4
33		311.0	137.36	24.35	4085.9
34		327.5	4.73	25.48	140.8
35	N-Ethyl acetamide	330.6	5.90	25.69	175.7
36		334.6	34.18	25.97	1016.8
37		344.2	102.40	26.63	3045.8
38		351.0	22.98		
39		355.8	18.82	27.42	560.0
40		360.2	8.90	27.73	264.9
41		364.3	14.41	28.01	428.7
42		371.2	16.27	28.48	484.0
43		378.2	3.32	28.96	98.8
44		382.3	2.67	29.24	79.6
45		385.4	4.26	29.45	126.9
46		392.5	8.50	29.94	253.0

TABLE E.22 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47	Acetamide	409.2	477.31	31.84	14197.4
48		412.4	7.91	32.31	235.4
49		416.7	2.92	32.95	87.1
50		420.2	28.54	33.48	849.0
51		426.1	3.39	34.37	101.0
Total concentration: 14217.9 ppm					

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Sample file: 98P675993.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

TABLE E.23 Initial Run of 675°F, 921 h Sample, Run before 575°F Data

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
1	Volatile region	11.2	4.04	0.90	102.1
2		13.1	1.69	1.05	42.8
3		13.3	1.63	1.07	41.2
4		14.4	4.34	1.16	109.7
5		15.6	158.29	1.25	4000.0
6		20.4	203.58	1.64	5144.5
7		23.3	71.95	1.87	1818.3
8		24.8	170.42	2.00	4306.5
9		32.0	204.17	2.58	5159.4
10		36.2	27.82	2.92	703.1
11	Pyridine region	41.2	366.22	3.32	9254.5
12		67.1	31.59		
13		69.9	117.40	5.64	2966.7
14		88.6	5.00	7.15	126.4
15		94.9	11.45	7.66	289.4
16		105.0	0.70	8.48	17.9
17		108.8	1.58	8.78	39.9
18		198.1	200.33	15.99	5062.4
19		200.0	604.05	16.14	15264.3
20		203.1	0.57	16.37	14.4
21	3-Methylpyridine	204.5	20.01	16.47	505.8
22		206.3	2.98	16.60	75.4
23		209.2	1732.73	16.81	43785.7
24		222.3	24.67	17.76	623.4
25		240.7	3795.67	19.08	95915.6
26		246.1	1121.17	19.47	28331.7
27		249.2	692.58	19.69	17501.6
28		252.1	770.34	19.90	19466.5
29		257.2	557.43	20.28	14086.2
30		262.2	944.18	20.63	23859.3
31	4-Methylpyridine	265.3	144.86	20.86	3660.6
32		271.1	9.07	21.28	229.3
33		274.0	80.59	21.49	2036.5
34		277.7	3.83	21.76	96.8
35		280.0	3.60	21.92	91.0
36		282.7	17.80	22.11	449.9
37		287.1	5.73	22.43	144.8
38		288.8	1.98		
39		290.4	9.12	22.67	230.6
40		293.1	1.50	22.87	38.0
41		296.9	1.64	23.14	41.5
42		299.0	1.16	23.29	29.4
43		302.0	6.19	23.51	156.4
44		304.1	4.04	23.66	102.3
45		305.8	3.48	23.78	88.1
46		308.1	6.61	23.95	167.2

TABLE E.23 (Cont'd)

Peak No.	Name	ARI	Conc. (ppm)	Ret. Time	Area ^a
47	Pyridine	315.4	75.69	24.48	1912.9
48		318.4	11.81	24.69	298.5
49		320.2	16.94	24.82	428.0
50		323.3	5.96	25.05	150.8
51		326.0	5.08	25.24	128.3
52		331.4	6.24	25.63	157.7
53		335.1	6.34	25.89	160.3
54		338.8	18.91	26.17	477.9
55		341.2	10.75	26.33	271.7
56		347.0	56.47	26.76	1427.0
57		348.5	34.37	26.86	868.6
58		350.7	5.14	27.02	130.0
59		354.2	15.74	27.27	397.8
60		359.0	13.24	27.62	334.6
61		363.4	8.35	27.94	211.0
62		366.1	4.01	28.13	101.3
63		368.1	4.75	28.28	120.1
64		370.3	3.77		
65		373.7	13.35	28.69	337.5
66		380.5	2.95	29.18	74.7
67		384.6	2.79	29.47	70.5
68		387.6	5.11	29.69	129.2
69		394.4	6.07	30.17	153.4
70		402.1	0.94	30.90	23.8
71	Acetamide	410.0	544.03	32.09	13747.6
72		411.4	2.06	32.30	52.2
73		413.3	5.68	32.57	143.5
74		415.5	0.48	32.90	12.2
75		416.4	1.08	33.03	27.4
76		417.6	3.05	33.22	77.2
77		419.4	3.47	33.49	87.7
78		420.9	20.60	33.72	520.6
79		427.1	4.75	34.65	120.1
80		428.3	1.39	34.83	35.3
Total concentration: 13071.5 ppm					

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Sample file: 67P675921.001a

^aArea is in a unit that is calibrated when the standard sample is analyzed.

APPENDIX F:
GAS CHROMATOGRAMS FOR
LOW BOILERS

Figures F.1-F.45 are the gas chromatograms in the low-boiling region of each liquid sample analyzed. All y-axes in the figures are in millivolts (mV); all x-axes are in minutes.

FIGURE F.1 Replotted Chromatograms at First and Last GC Runs of the Analytical Standard

FIGURE F.2 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 0 h

FIGURE F.3 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 0 h, scale expanded 10x

FIGURE F.4 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 18 h

FIGURE F.5 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 18 h, scale expanded 10x

FIGURE F.6 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 161 h

FIGURE F.7 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 161 h, scale expanded 15x

FIGURE F.8 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 329 h

FIGURE F.9 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 329 h, scale expanded 20x

FIGURE F.10 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 532 h

FIGURE F.11 Replotted Chromatograms of Low-Boiler Degradation Products: 575°F, 532 h, scale expanded 20x

FIGURE F.12 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 21 h

FIGURE F.13 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 21 h, scale expanded 20x

FIGURE F.14 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 189 h

FIGURE F.15 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 189 h, scale expanded 20x

FIGURE F.16 Replotted Chromatograms Low-Boiler
Degradation Products: 625°F, 359 h

FIGURE F.17 Replotted Chromatograms of Low-Boiler
Degradation Products: 625°F, 359 h, scale expanded 30x

FIGURE F.18 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 525 h

FIGURE F.19 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 525 h, scale expanded 30x

FIGURE F.20 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 694 h

FIGURE F.21 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 694 h, scale expanded 10x

FIGURE F.22 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 837 h

FIGURE F.23 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 837 h, scale expanded 10x

FIGURE F.24 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 1153 h

FIGURE F.25 Replotted Chromatograms of Low-Boiler Degradation Products: 625°F, 1153 h, scale expanded 10x

FIGURE F.26 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 0 h

FIGURE F.27 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 0 h, scale expanded 10x

FIGURE F.28 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 22 h

FIGURE F.29 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 22 h, scale expanded 10x

FIGURE F.30 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 191 h

FIGURE F.31 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 191 h, scale expanded 10x

FIGURE F.32 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 359 h

FIGURE F.33 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 359 h, scale expanded 10x

FIGURE F.34 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 514 h

FIGURE F.35 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 514 h, scale expanded 10x

FIGURE F.36 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 532 h

FIGURE F.37 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 532 h, scale expanded 10x

FIGURE F.38 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 678 h

FIGURE F.39 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 678 h, scale expanded 10x

FIGURE F.40 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 850 h

FIGURE F.41 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 850 h, scale expanded 10x

FIGURE F.42 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 921 h

FIGURE F.43 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 921 h, scale expanded 10x

FIGURE F.44 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 993 h

FIGURE F.45 Replotted Chromatograms of Low-Boiler Degradation Products: 675°F, 993 h, scale expanded 10x