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Study of Toluene Stability for an Organic Rankine Cycle Space-Based Power System

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APPENDICES

ACRONYM LIST

CRT	Cathode Ray Tube
DIPS	Dynamic Isotope Power System
GC	Gas Chromatograph
LeRC	Lewis Research Center
NASA	National Aeronautics and Space Administration
NC	Noncondensible
NPSH	Net Positive Suction Head
NVR	Nonvolatile Residue
ORC	Organic Rankine Cycle
PCU	Power Conversion Unit
P-H	Pressure-Enthalpy
PLR	Parasitic Load Radiator
RFMD	Rotary Fluid Management Device
SCC	Standard Cubic Centimeter
SD-ORC	Solar Dynamic-Organic Rankine Cycle

1.0 Introduction

The Heat Engine Technology Development Program was initiated August 29, 1985 under Contract No. NAS3-24663 as part of the Space Station Advanced Development Program. The contract was awarded to Sundstrand Energy Systems by NASA-Lewis Research Center. Task Order 1 was initiated on October 18, 1985. This task covered the design, fabrication, instrumentation, calibration, assembly, checkout and endurance operation of a dynamic test loop to evaluate the thermal stability of an organic Rankine cycle (ORC) working fluid, toluene, for potential application to the Space Station Power Conversion Unit (PCU). This document describes the experiment and presents the test results.

2.0 Summary

The investigation was carried out in a dynamic test loop in which the working fluid, toluene, was circulated through a heater, simulated turbine, regenerator, condenser and pump to duplicate the conditions in an actual ORC system. The maximum working fluid temperature was at the turbine simulator inlet. That temperature was maintained at 750°F for the majority of the operating time. Several short excursions to 850°F were also performed. The total operating time for this experiment was 3410 hours.

Samples of noncondensible gases and liquid toluene were taken periodically during the test. The samples were analyzed to identify the degradation products formed and the quantity of these products. From these data, it was possible to determine the degradation rate of the working fluid and the generation rate of noncondensible gases.

A further goal of this work was to relate the degradation observed in a dynamic operating loop to degradation obtained in isothermal capsule tests. This relationship could then be used to estimate the degradation in the Space Station SD-ORC. A thermal analysis of the test loop was prepared and the expected amount of degradation was predicted based on capsule test data. This technique is further described in Section 3 of this report. This was then compared to the actual degradation observed in the test loop.

The results obtained from the toluene stability loop verify that a method for predicting the pyrolytic degradation of toluene has been developed. For the Space Station ORC application of 750°F, the analytical method verified by this test program predicts 1% degradation of the working fluid inventory over the 30-year mission life. This calculation was performed as a part of the Phase B preliminary design effort and is described in the Phase B documentation. Based on post-test property measurements of partially degraded toluene, 1% degradation of the working fluid would not have a detectable impact on system performance. The identity of the degradation products and the low rates of formation were as expected from toluene capsule test data. The toluene was also shown to be tolerant to periods of over-temperature exposure. The analytical method verified by this program can be applied to other ORC applications to predict working fluid degradation.

The key results and conclusions of this test program are summarized in Table 1.

TABLE 1

Key Results and Conclusions

-3410 total test hours
  -3401 hours total at 750°F
  -2996 hours continuous at 750°F
  -9 hours at 850°F

-96% ratio of test hours to clock hours

-the identity of toluene degradation products were as expected from capsule tests
  -all products are non-corrosive
  -soluble liquid products
  -noncondensible gas products

-the formation rates of gas and liquid degradation products were established for the 750°F test
  -measured rates are below predicted rates based on capsule test data

  -liquid degradation rate *
    -measured = 0.00243 grams non-toluene/hour
    -predicted = 0.00265 grams non-toluene/hour
  -gas formation rate *
    -measured = 0.07 scc/hour
    -predicted = 0.27 scc/hour

-the fluid was crystal clear after 3410 hours

-three excursions to 850°F were performed
  -no impact on liquid degradation was detected
  -noncondensible gas generation rate was higher than at 750°F, but the rate was as expected from capsule test calculations

-post-test disassembly inspection of the hardware found no visual or chemical evidence of insoluble toluene degradation products

-post-test property measurements of 0.34% degraded toluene found a negligible difference when compared to pure toluene

* These are loop specific rates and cannot be directly applied to other configurations.

3.0 Background

All organic fluids undergo chemical changes when heated to a sufficiently high temperature (pyrolytic degradation). At elevated temperatures certain molecular bonds break, forming noncondensible gases and soluble liquid products. An accumulation of degradation products could potentially affect the operation of a power system. The primary concerns associated with the degradation of the ORC working fluid are: (1) the accumulation of liquid degradation products has the potential for altering the bulk fluid properties and thereby affecting the heat transfer processes with a resultant loss in cycle performance and (2) the accumulation of noncondensible gases can alter the heat transfer characteristics in the condenser and result in a rise in turbine back pressure which ultimately results in a decrease in the cycle efficiency. Both of these conditions are "wear-out" types of concerns that would result in a slow deterioration of cycle performance over the mission life.

The organic working fluid selected for this program was toluene. A preliminary review of the candidate working fluids was based on physical and chemical properties of each fluid compared to the requirements of the application and the ability to provide optimum cycle efficiency. Several fluids were identified as potentially acceptable for the Space Station application and required closer examination. The detailed comparison included such categories as cycle efficiency, thermal degradation, chemical properties, fluid properties, flammability, toxicity, experience and availability. Sundstrand and NASA-LeRC reached a joint decision to select toluene as the working fluid to be studied based on the results of this comparison. Toluene is also the baseline working fluid for the Space Station solar dynamic ORC power application.

The basic approach to all thermal stability testing consists of heating a fluid to a known temperature, taking fluid samples periodically, analyzing the samples for chemical changes and then relating these changes to time. Two classical methods of thermal stability testing are capsule testing and dynamic loop testing. Temperature and time are the key variables in both of these methods.

Capsule testing is a static type test because the fluid does not circulate during the test. Capsules are typically stainless steel bottles in which small amounts of fluid are sealed for isothermal heating in an oven for a predetermined period of time. If the above procedure is repeated for many oven temperatures, degradation rates can then be determined for each of these temperatures. By plotting these degradation rates versus the corresponding oven temperatures, fluid degradation can be expressed as a function of temperature. Sundstrand performed a series of toluene capsule tests in 1971 and Argonne National Laboratory repeated the capsule tests and verified the results in 1986.[10] The capsule tests assume a constant rate of degradation.

Dynamic loop testing is another method of thermal stability testing. In this method, fluid is circulated through a heat transfer system known as the dynamic test loop. Major loop components include a heater, a cooler and a pump. The dynamic test loop is typically designed with liquid and noncondensible gas sampling ports, where fluid samples can be periodically drawn off for chemical analysis. As with the capsule testing, noncondensible gas and liquid degradation rates are determined by plotting measured degradation versus dynamic loop operation time. Sequential testing can be performed to determine temperature sensitivity.

Dynamic loop testing is the preferred method of thermal stability testing because dynamic loop tests more accurately reflect fluid degradation observed in a full-scale power system.

The objective of this program was to determine the thermal stability of toluene under actual ORC operating conditions. To achieve this objective, a test loop was designed and fabricated to subject the chosen working fluid to the chemical and thermodynamic conditions of an actual power conversion system. Samples of the noncondensible gas and liquid toluene were taken periodically during the test and chemically analyzed. The measured degradation rates were then compared to capsule-based analytical predictions of degradation.

The degradation rate is exponentially related to temperature and therefore it can be shown that virtually all degradation in a loop or system occurs in the vaporizer. The method of using capsule results to predict loop or system degradation focuses on an analysis of the vaporizer. The vaporizer is divided into a number of segments. For each segment, the mass contained and average temperature are determined. Capsule results for degradation are applied to each element mass at the operating temperature. The degradation formed in each element is then summed to determine the vaporizer overall degradation rate. Because the degradation products are soluble, they do not accumulate in the vaporizer. It is assumed they are uniformly distributed throughout the entire loop or system inventory. In this way, the loop or system degradation rate is predicted for both liquid and non-condensable degradation products. An example of this technique analyzing the loop vaporizer profile and then applying capsule results to predict loop degradation is presented in Appendix A and B, respectively.

4.0 Loop Design and Construction

4.1 Loop Description

The Solar Dynamic Organic Rankine Cycle (SD-ORC) is a candidate for the Power Generation System that will convert solar energy into electrical power for the Space Station. A Functional Block Diagram is shown in Figure 1. The Rocketdyne Space Station Phase B concept consists of an offset parabolic concentrator that focuses solar energy on a receiver.[6] The receiver absorbs the solar energy as heat. A power conversion unit (or heat engine) converts the thermal energy into electrical power. A heat pipe radiator rejects the excess energy from the system.

The heart of the SD-ORC is the heat engine that converts thermal energy into electrical power. This is accomplished by pumping a supercritical working fluid (toluene) through the solar receiver to absorb heat. Superheated toluene exits the receiver and drives a single stage axial impulse turbine. An alternator is integrally mounted to the turbine shaft and provides electrical power to the user. The balance of the system components condense and pressurize the working fluid to complete the cycle. Due to the selection of a supercritical heat addition process, the only two-phase interfaces in the SD-ORC are in the heat rejection zone.

The design of the toluene stability loop constructed under the Advanced Development contract was based on state points of the proposed Solar Dynamic Organic Rankine Cycle (SD-ORC) Power System for the Space Station. A schematic diagram of the cycle with corresponding state points is shown in Figure 2.

The key state point of the SD-ORC design which was identically matched in the dynamic loop was at the turbine inlet: 750^{o}F and 614 psia. The majority of working fluid degradation takes place in the heater section of the cycle. This is because the degradation rate exponentially increases with temperature as shown in Figure 3. Figure 3 is a plot of isothermal toluene capsule results and shows the relationship of degradation rate to temperature.[10] The state points in the cold end of the cycle were modified slightly for this experiment. The condenser pressure for the Space Station application is subatmospheric (approximately 3 psia).

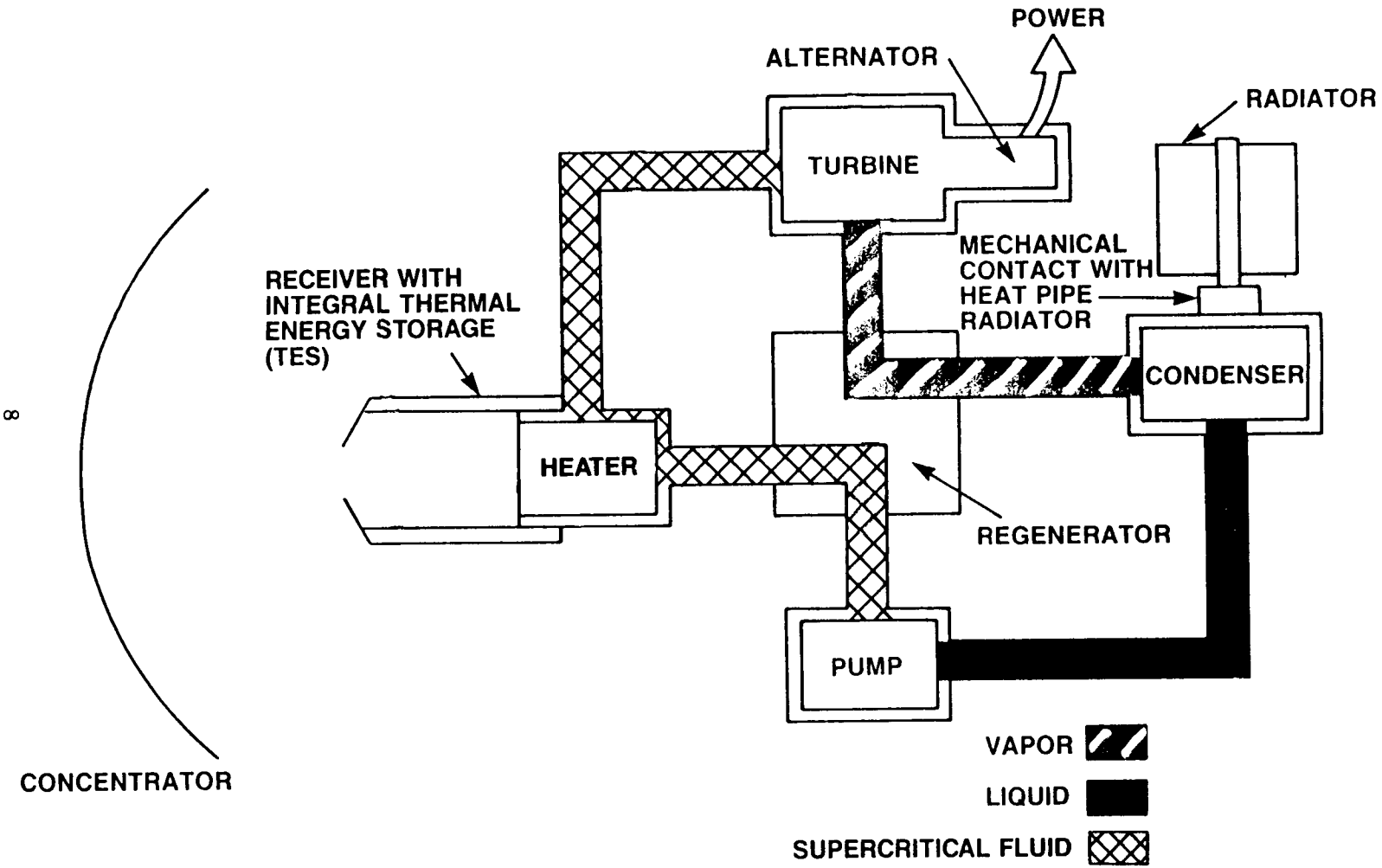
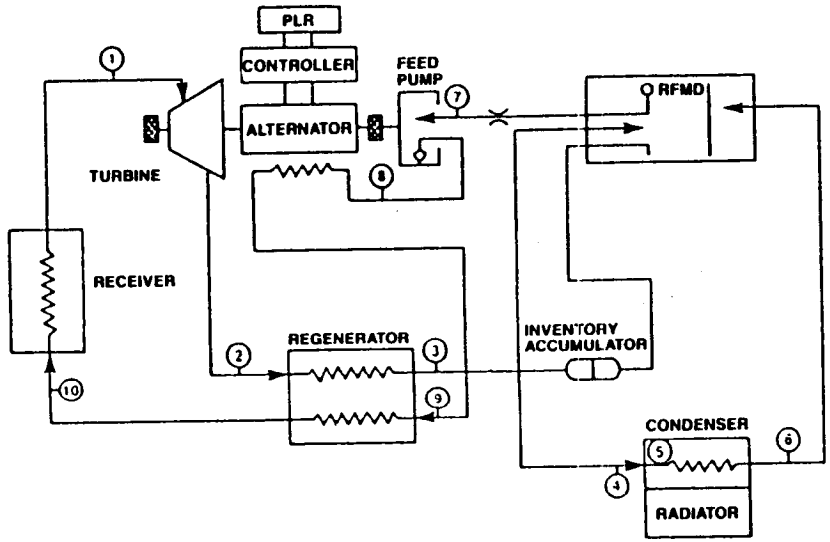


FIGURE 1 SD-ORC FUNCTIONAL BLOCK DIAGRAM



STATE POINTS

Location	Description	Temperature °C	Temperature °F	Pressure kPa	Pressure psia	Mass Flow kg/s	Mass Flow lb/s
1	Turbine Inlet	674	755.0	4233	614.00	.198	.436
2	Regenerator Vapor In	560	548.8	21.3	3.09	.198	.436
3	Regenerator Vapor Out	353	176.2	20.3	2.94	.198	.436
4	Condenser Vapor In	353	176.2	16.8	2.44	.188	.415
5	Condenser Saturated Vapor	331	135.7	16.8	2.44	—	—
6	Condenser Exit	307	92.5	7.3	1.06	.188	.415
7	Feed Pump Inlet	329	132.4	15.6	2.27	.198	.436
8	Feed Pump Exit	335	143.0	4944	717.10	.198	.436
9	Regenerator Liquid In	341	154.6	4888	709.10	.198	.436
10	Regenerator Liquid Out	504	448.1	4654	675.00	.198	.436

FIGURE 2 SD-ORC SCHEMATIC AND STATE POINTS

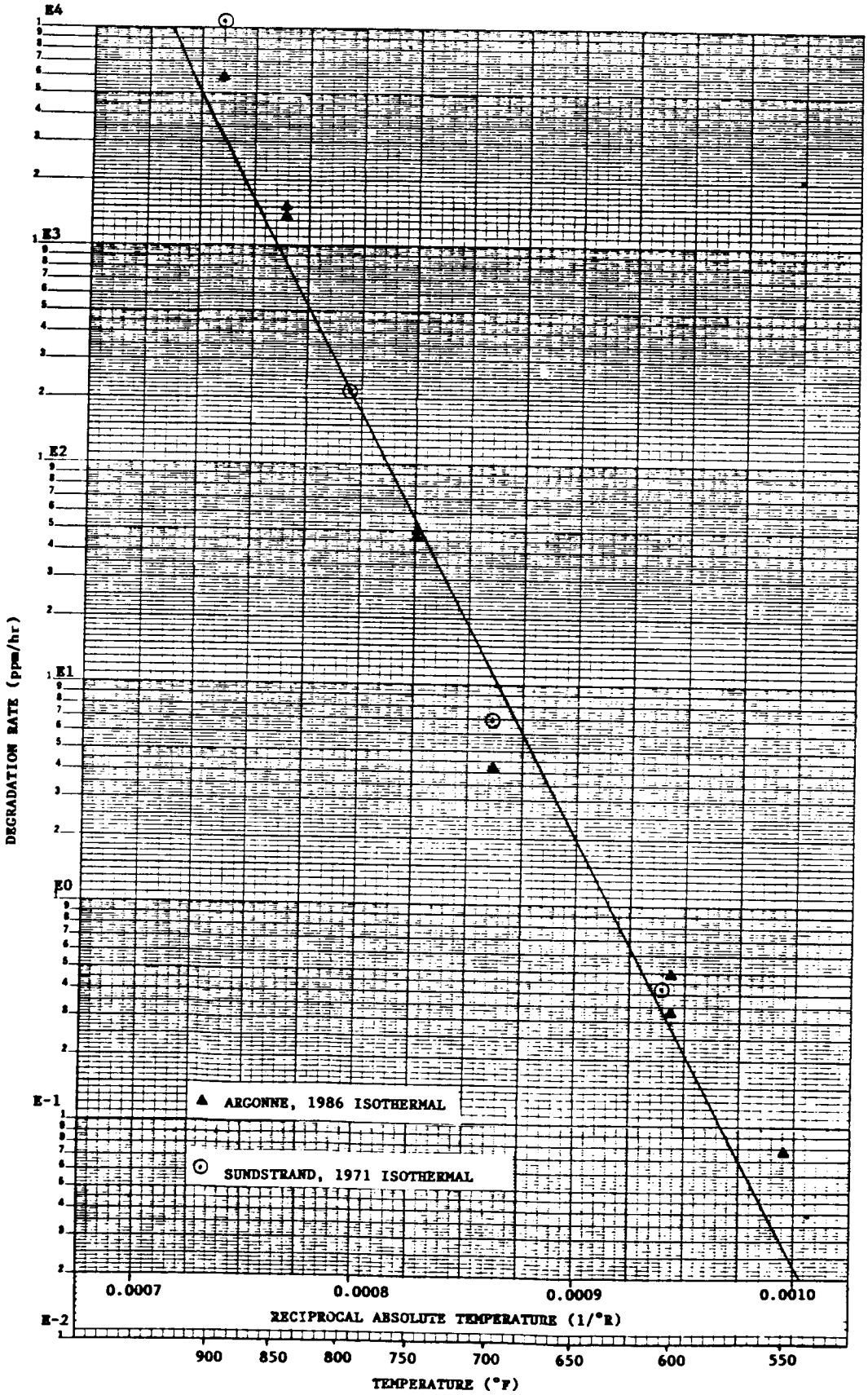


FIGURE 3 TOLUENE ISOTHERMAL CAPSULE TEST RESULTS

Operating a subatmospheric dynamic loop for extended periods of time at ambient environmental conditions raises the potential for air in-leakage. Based on previous experience it was known that oxygenation of the toluene results in significantly higher degradation rates. For the subject dynamic loop the condenser design operating pressure was superatmospheric (approximately 20 psia). The effect on fluid degradation was negligible and operating the system at superatmospheric conditions limited the potential for air-in-leakage. During the experiment there were several shutdowns during which the loop cooled to a sub-atmospheric condition. Operating experience is described in Section 5.1. The correspondence of test loop state points to proposed Space Station conditions is given in the pressure-enthalpy diagram, Figure 4. The dynamic loop flow rate was sized for the salt bath heater assembly that was available. The equivalent power conversion unit electrical rating of the dynamic loop was approximately 4 Kwe versus 25 Kwe for the Space Station application.

Figure 5 is a schematic of the test loop constructed for this project. The major components of the loop included a salt bath toluene heater, turbine simulator, regenerator, condenser, pump, pulsation damper, sampling stations, instrumentation, controls and automated safety systems.

The toluene heater (drawing ED 16310) consisted of a helically wound tube submerged in a bath of molten salt. A salt bath heater provides a significant advantage because the concern associated with over-temperature exposure of the fluid in the case of a system shutdown is virtually eliminated due to the small delta T between the molten salt and the working fluid outlet.

The heater tubing was fabricated from annealed 316 stainless steel with tube dimensions of 0.50 inch OD x 0.035 inch wall x 70 feet long. The tubing was formed into two nested helically wound coils approximately 15 inches in diameter. Six thermocouples were silver soldered to the tubing at equally spaced lengths to provide a map of the tubing wall temperature versus length. The salt used for this experiment was "Holden Tempering 350 pink". Six 5 Kw electric resistance heater elements were submerged in the salt. The heater elements were controlled to maintain a specified salt bath temperature. A positive pressure nitrogen blanket surrounded the molten salt bath and electric resistance heaters to prevent moisture

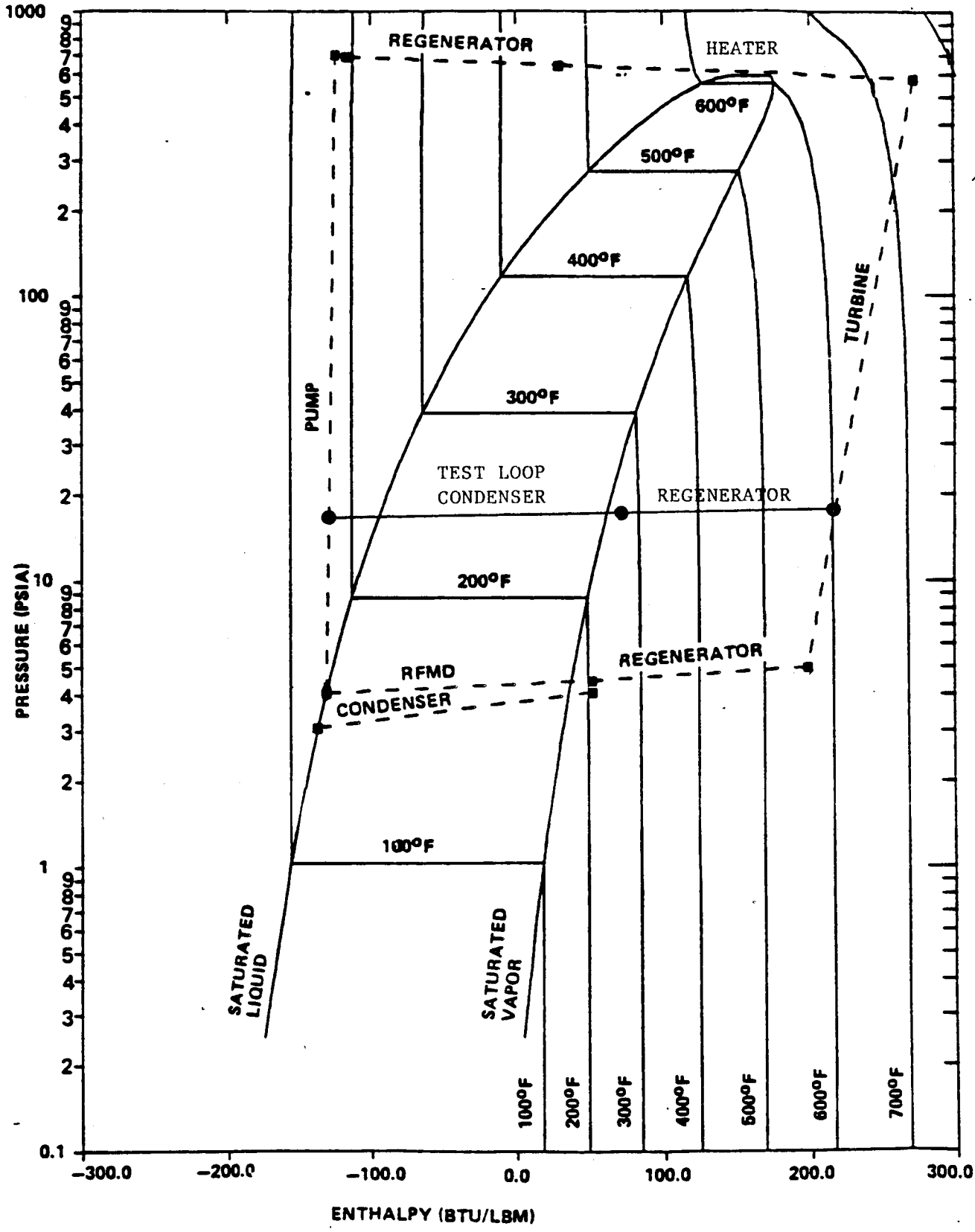


FIGURE 4 ORC POWER CYCLE PRESSURE-ENTHALPY CHART (TOLUENE WORKING FLUID)

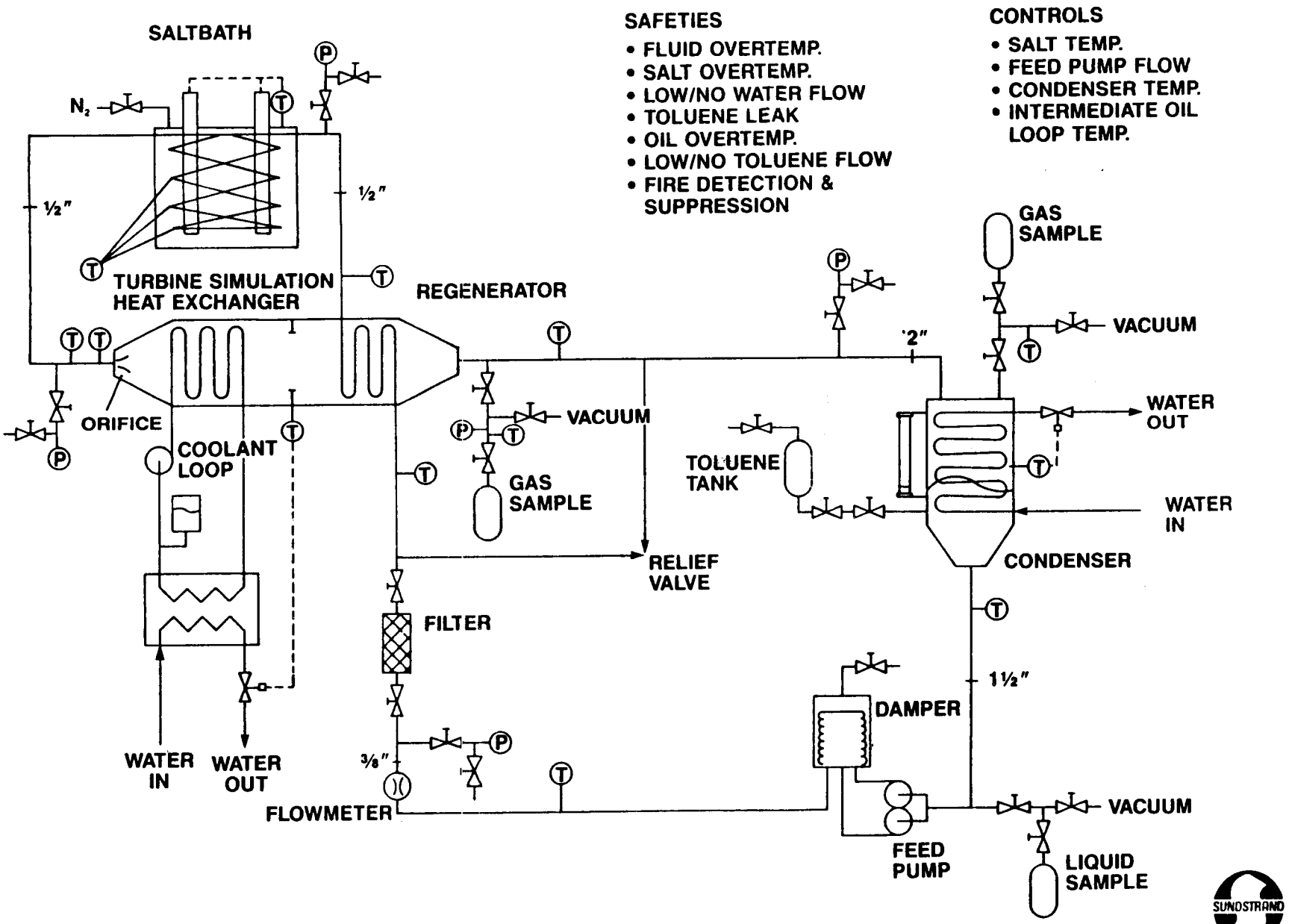


FIGURE 5 NASA TOLUENE STABILITY LOOP

or oxygen exposure of the heater terminals. Figure 6 shows the major pieces of the salt bath heater assembly: helically wound tubing, salt container and outer container. Figure 7 shows a top view of the assembled salt bath. The external box at the border of the photo was sealed to contain the nitrogen pressure blanket. The red caps are part of the heater elements that extend down into the salt. A typical heater element is shown in Figure 8.

The turbine simulator used for the test loop was comprised of two elements: an orifice and a small coiled tubing heat exchanger. A sharp-edged orifice was used to simulate the pressure drop across the turbine in the Space Station application. A heat exchanger simulated the temperature drop associated with a turbine. A heat transfer fluid, Therminol 66, was pumped through the coiled tubing to extract energy from the superheated toluene vapor stream. The turbine simulator and regenerator were combined into a single heat exchanger assembly (EP2809-1803). Figure 9 shows the major pieces of the heat exchanger assembly. The regenerator has cool liquid toluene inside the tubing and warm toluene vapor on the outside of the tubing (Refer to schematic Figure 5). The regenerator functions as a liquid preheater and a vapor desuperheater.

The condenser assembly (EP2809-1802) was similar in construction to the turbine/regenerator heat exchanger assembly. The condenser shown in Figure 10 was a bare tube coil containing water. Condensation of the toluene vapors occurred on the cold surfaces of the tubing. The liquid toluene condensate was subcooled by the cold water in the tubing. The flow of cooling water through the tubing was regulated to maintain a constant temperature in the vapor volume. A sight glass provided a visual indication of the depth of liquid in the condenser.

Figure 11 is a close-up of several key components. The toluene pump was a duplex diaphragm pump (Crane Metering Pump P/N XL 602-33-9-SM). The net positive suction head (NPSH) for the pump was provided by the elevation of the liquid level in the condenser mounted above the pump. The nature of a positive displacement diaphragm pump results in pressure pulsations that dictated the use of a pulsation damper. Two models of dampers were used

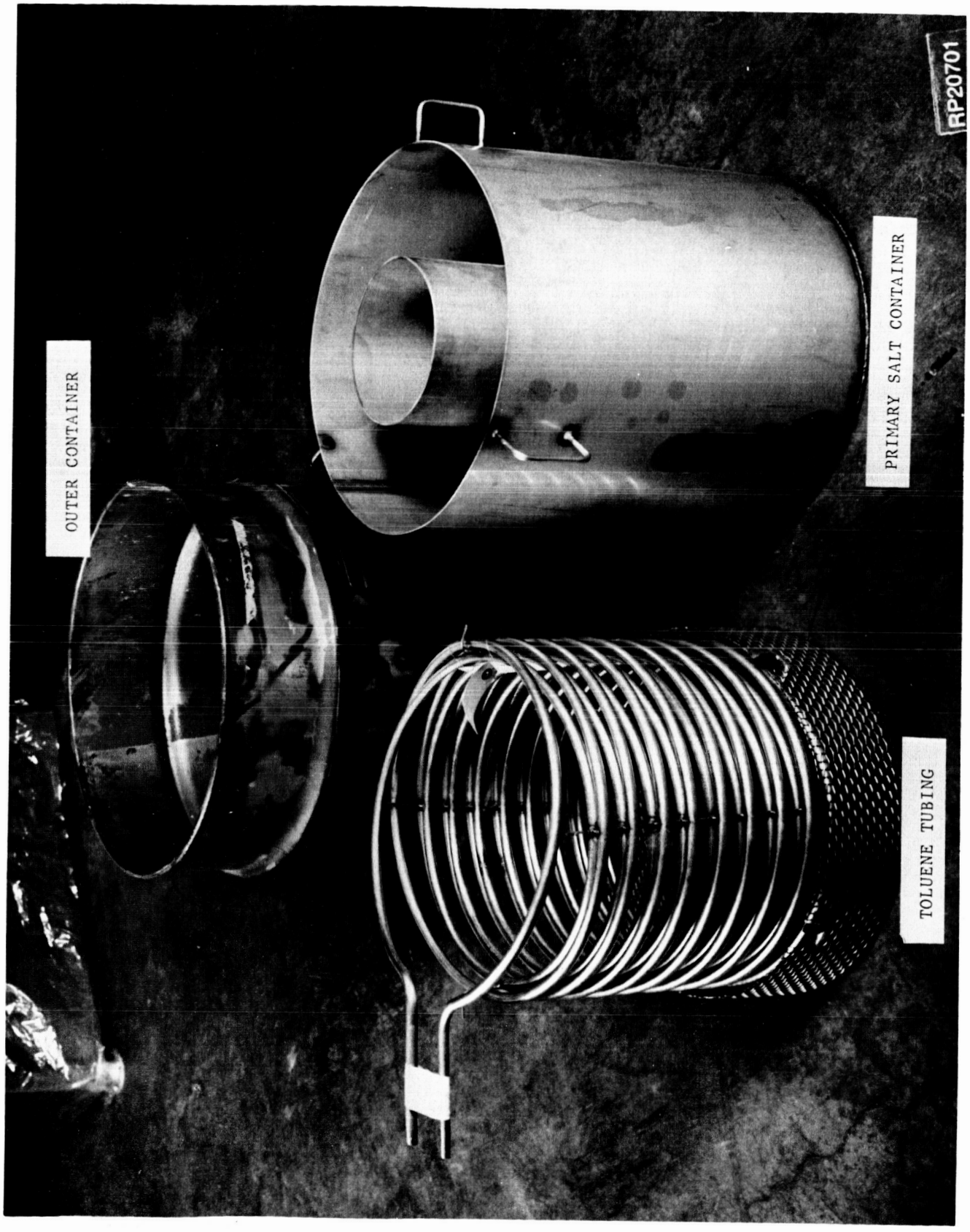


FIGURE 6 SALT BATH COMPONENTS

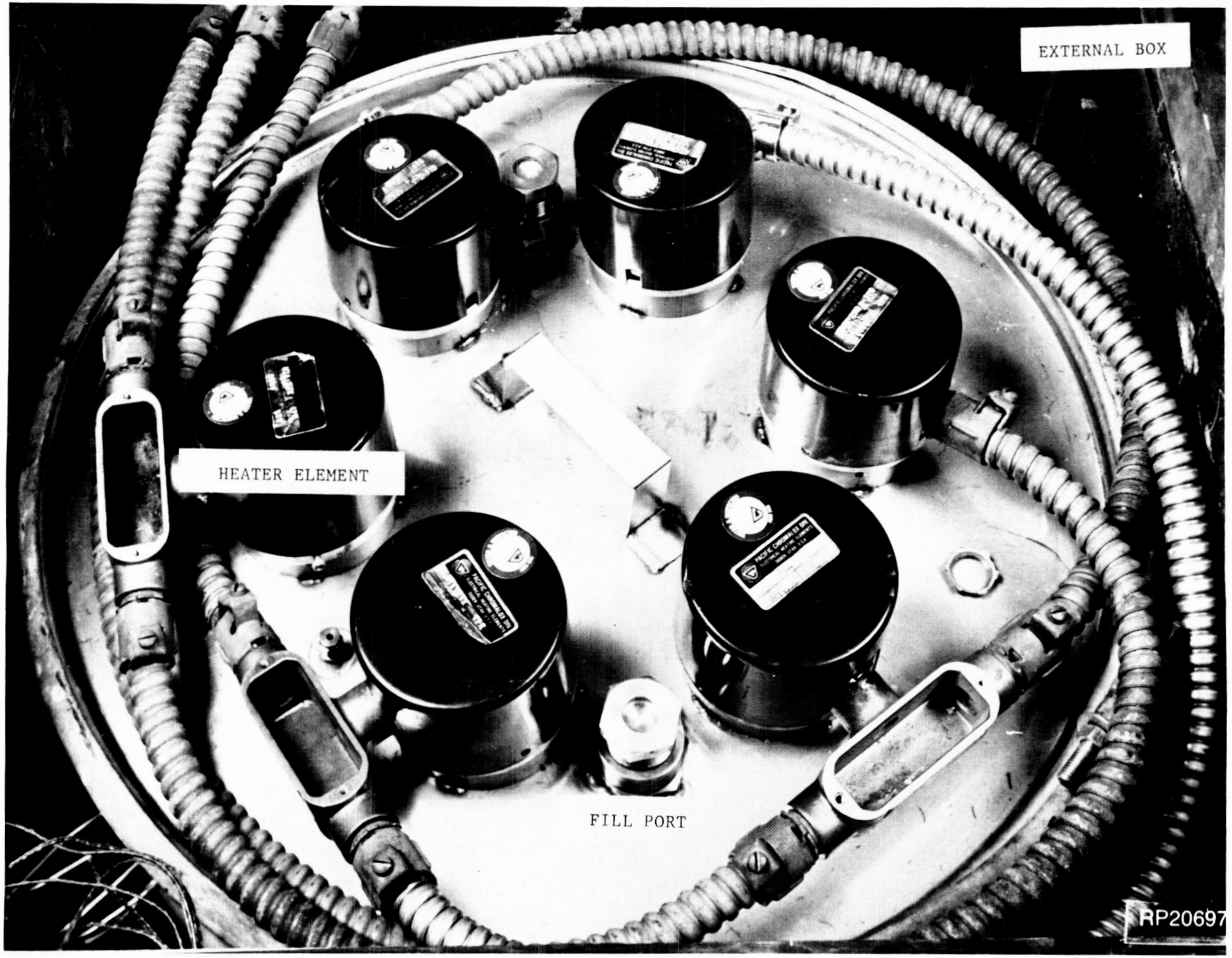


FIGURE 7 SALT BATH HEATER ASSEMBLY

FIGURE 8 HEATER ELEMENT

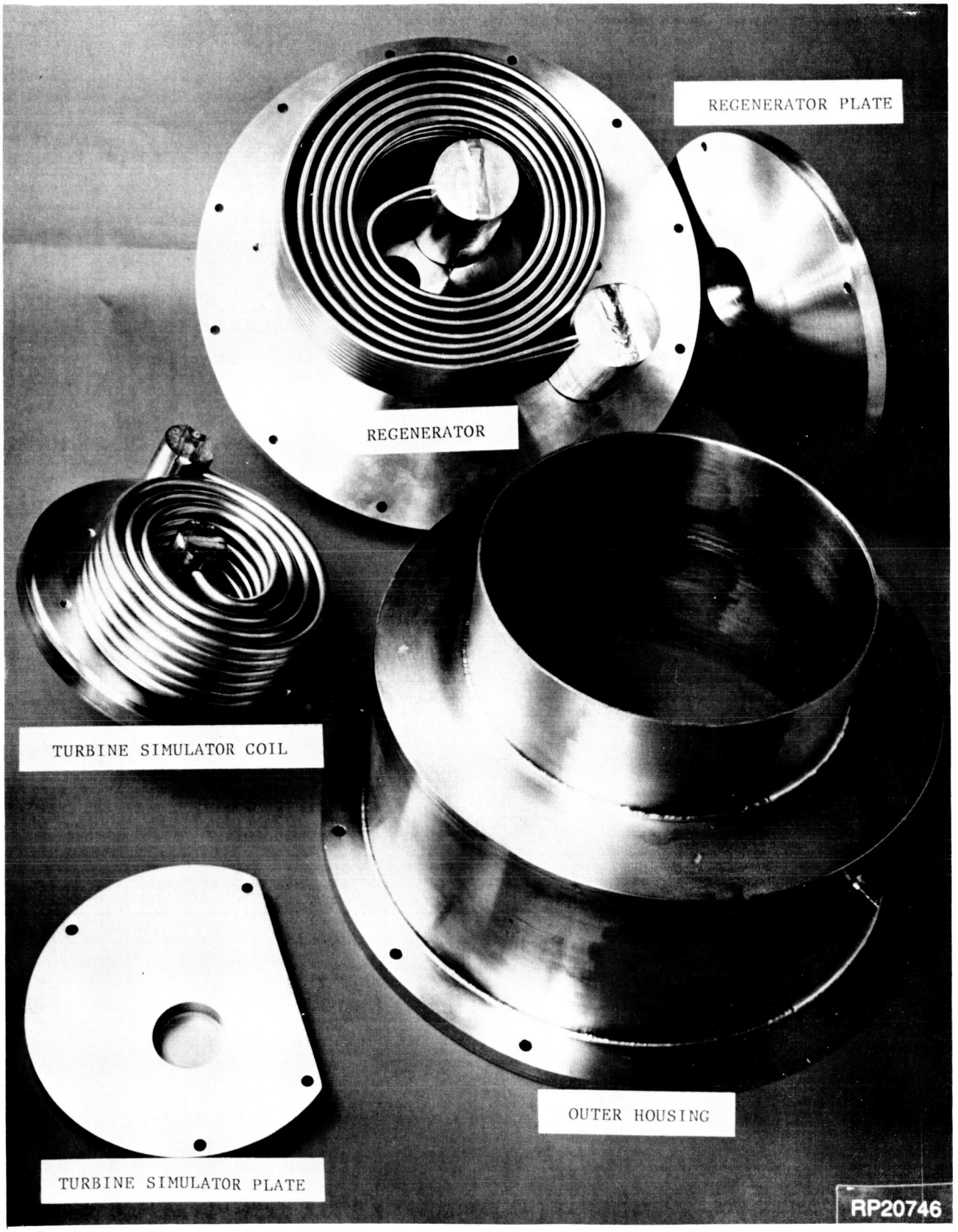


FIGURE 9 TURBINE SIMULATOR/REGENERATOR ASSEMBLY

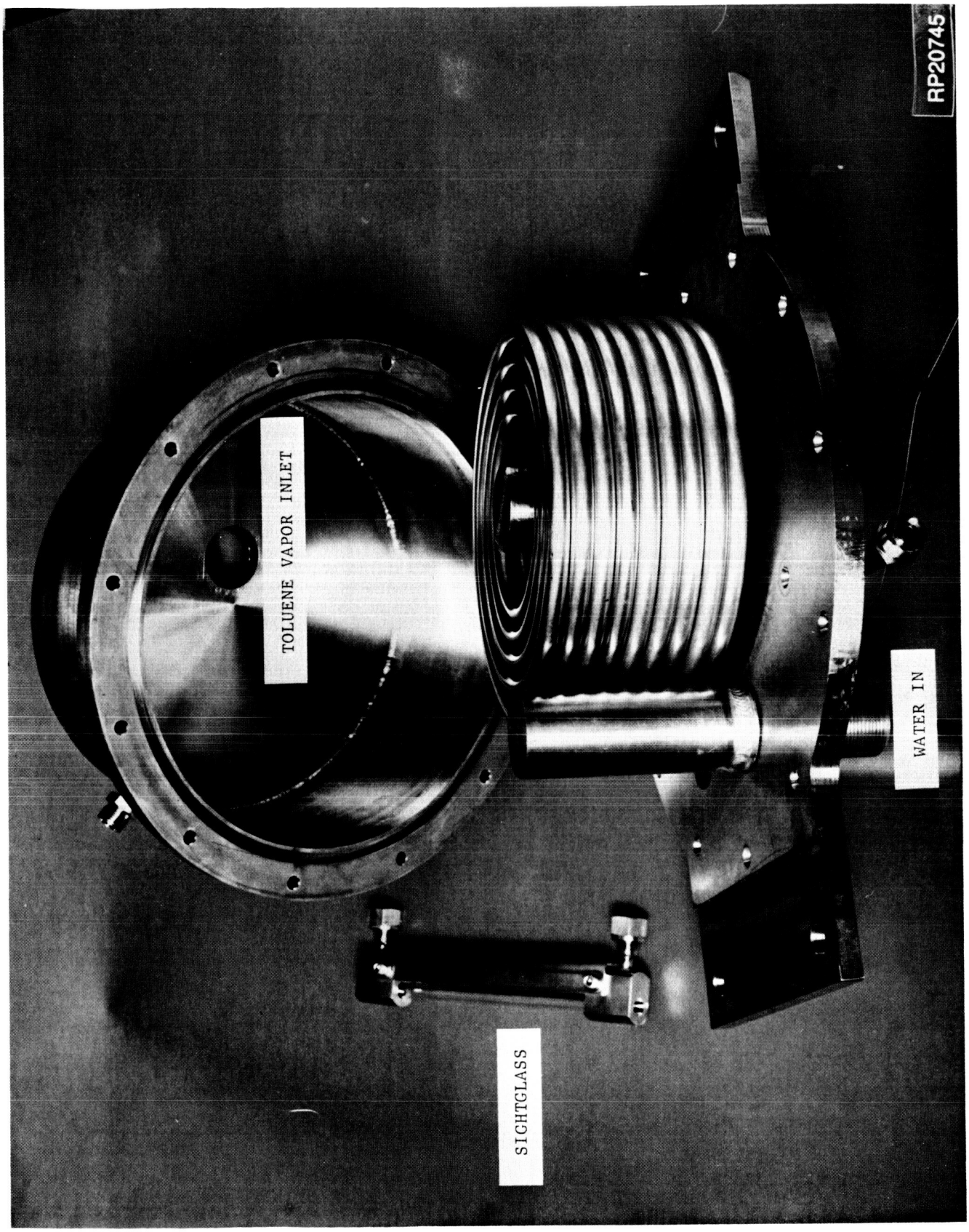


FIGURE 10 CONDENSER ASSEMBLY

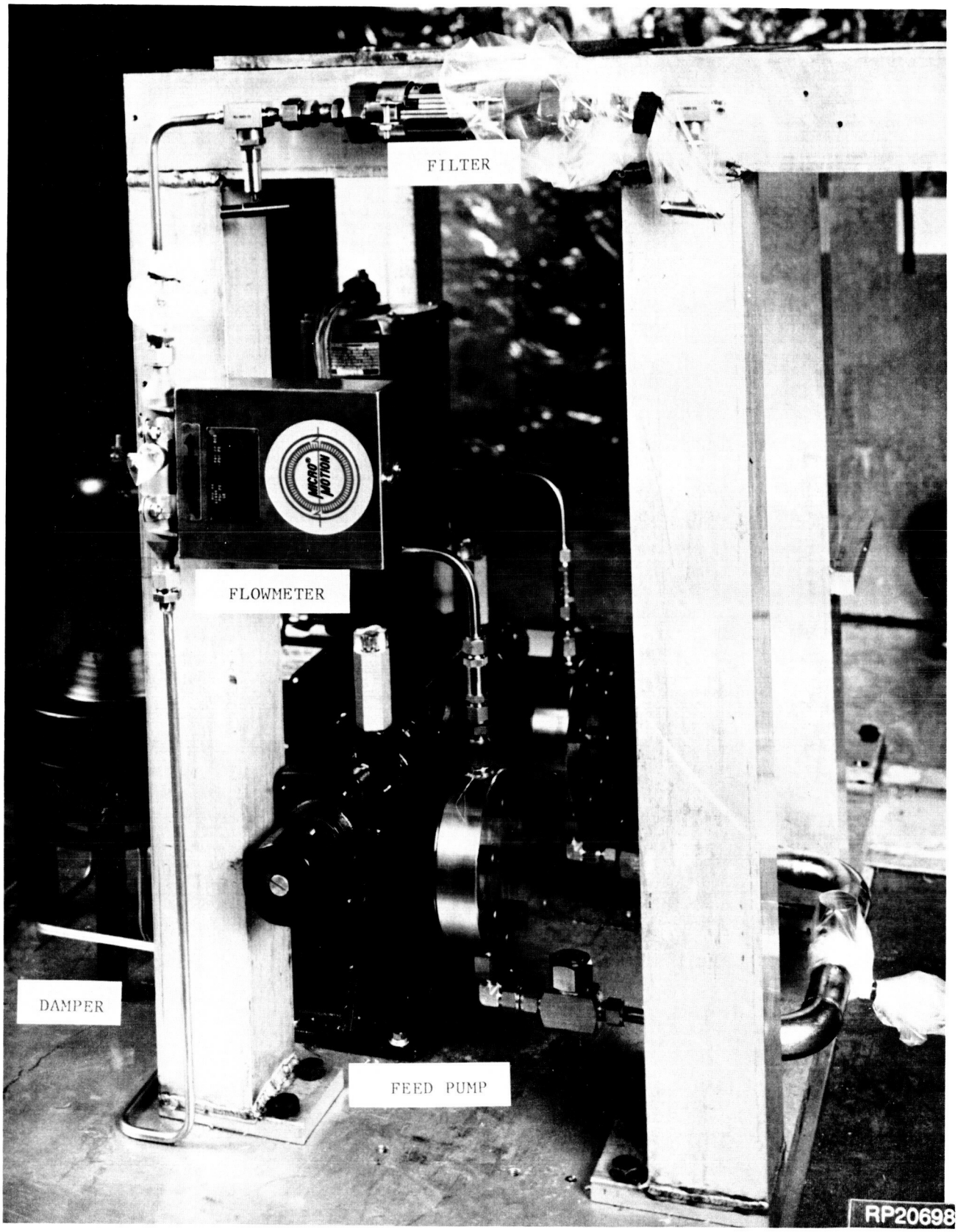


FIGURE 11 KEY COMPONENTS

during this experiment. The first unit (Liquid Dynamics P/N FBC 4S10D105347) is shown in Figure 11 and was replaced after repeated diaphragm ruptures prior to initiating endurance testing. The second unit (Flexicraft P/N 84182-P4) operated for the majority of the test and is visible in Figure 14. The pulsation damper was initially pressurized with nitrogen but to aid in assessing the in-leakage during shutdown periods, the pressurant was subsequently changed to argon. The toluene flow was measured in a direct mass flow meter (Micromotion Model D40). An in-line toluene filter (10 micron nominal, 25 micron absolute) was installed for post-test inspection of insoluble products collected in the filter element.

Key parameters were monitored throughout the loop with type K thermocouples and strain gauge pressure transducers. Data acquisition was performed with a MACSYM 150 and 250 system. A digital data display was available in real time on a cathode ray tube (CRT) with hard copies of data available at preset automated intervals. An analog Brush recorder was also used to record key parameters. Figure 12 shows the major components in the control room (from left to right): brush recorder, control console, MACSYM data acquisition system and printer.

4.2 Loop Fabrication and Fluid Preparation

Several unique considerations were employed in the fabrication and preparation of the toluene stability loop. Previous Sundstrand ORC experience provided many of the guidelines and procedures for this test program. Preventing air from entering the fluid system and verifying the cleanliness of all wetted parts were primary considerations. A further consideration was in the choice of materials. All of the materials of construction in contact with the toluene were compatible with the working fluid: 300 series stainless steel, viton [R] and teflon [R].

Preventing contamination of the fluid inventory with air was of the utmost importance in designing, constructing and operating this system. Based on

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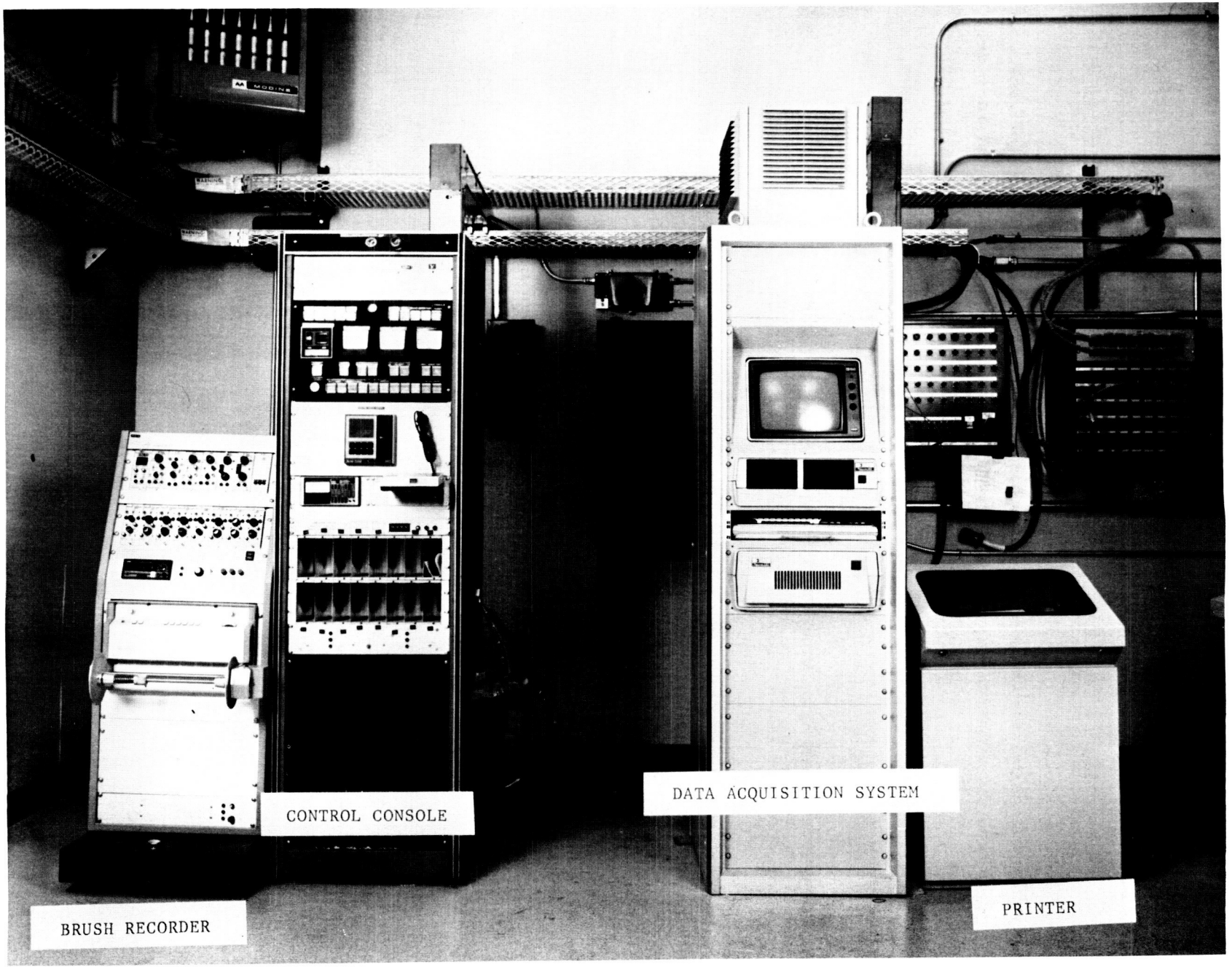


FIGURE 12 CONTROLS AND DATA ACQUISITION

previous ORC experience, the presence of oxygen and water in air will result in greatly increased levels of fluid degradation. To minimize the number of potential leak paths in the assembled loop, all of the fluid connections were welded except for a few critical connections around key loop components. The mechanical fluid connections were a viton o-ring face seal design. All of the valves specified for this application were hermetic, welded bellows valves. The finished fluid system joints were helium mass spectrometer leak checked to 1×10^{-6} scc/second.

As previously discussed, the system was maintained at a superatmospheric pressure to prevent air-in-leakage. All pressure transducer and sampling stations were provided with a valve arrangement to prevent ingestion of air during calibration of a pressure transducer or the sampling procedure. One valve isolated the transducer or bottle from the active system. A second valve was teed into the isolated line and was used to evacuate the trapped air volume in the line prior to opening the isolation valve to bring the transducer or sample bottle back into the active circuit.

Prior to starting the endurance portion of the test program, a significant amount of attention was devoted to preparing the fluid inventory. Room temperature liquid toluene contains dissolved air to approximately 11% by volume that would cause products of oxidation to appear in the endurance test sample analysis. A degassing procedure was developed that required that the liquid toluene be frozen. A vacuum pump evacuated the vapor space above the liquid during the freezing and thawing cycle. Toluene freezes at $-139^{\circ}F$, which necessitated the use of liquid nitrogen ($-320^{\circ}F$). The freeze and thaw cycle was performed a total of three times on all the fluid introduced in the test loop. Three cycles was an artibrary selection based on previous experience as being a good compromise in time and cost against air removal efficiency. Figure 13 shows the container used to prepare the toluene.

Cleanliness of the internal surfaces of the toluene stability loop was a high priority since any contamination source could lead to apparently higher working fluid degradation. To implement this requirement, each individual piece part of the system was precision cleaned per Sundstrand specification CP 14.57-01. The cleaning procedure described in the specification is performed with Freon TF conforming to MIL-C-81302. The

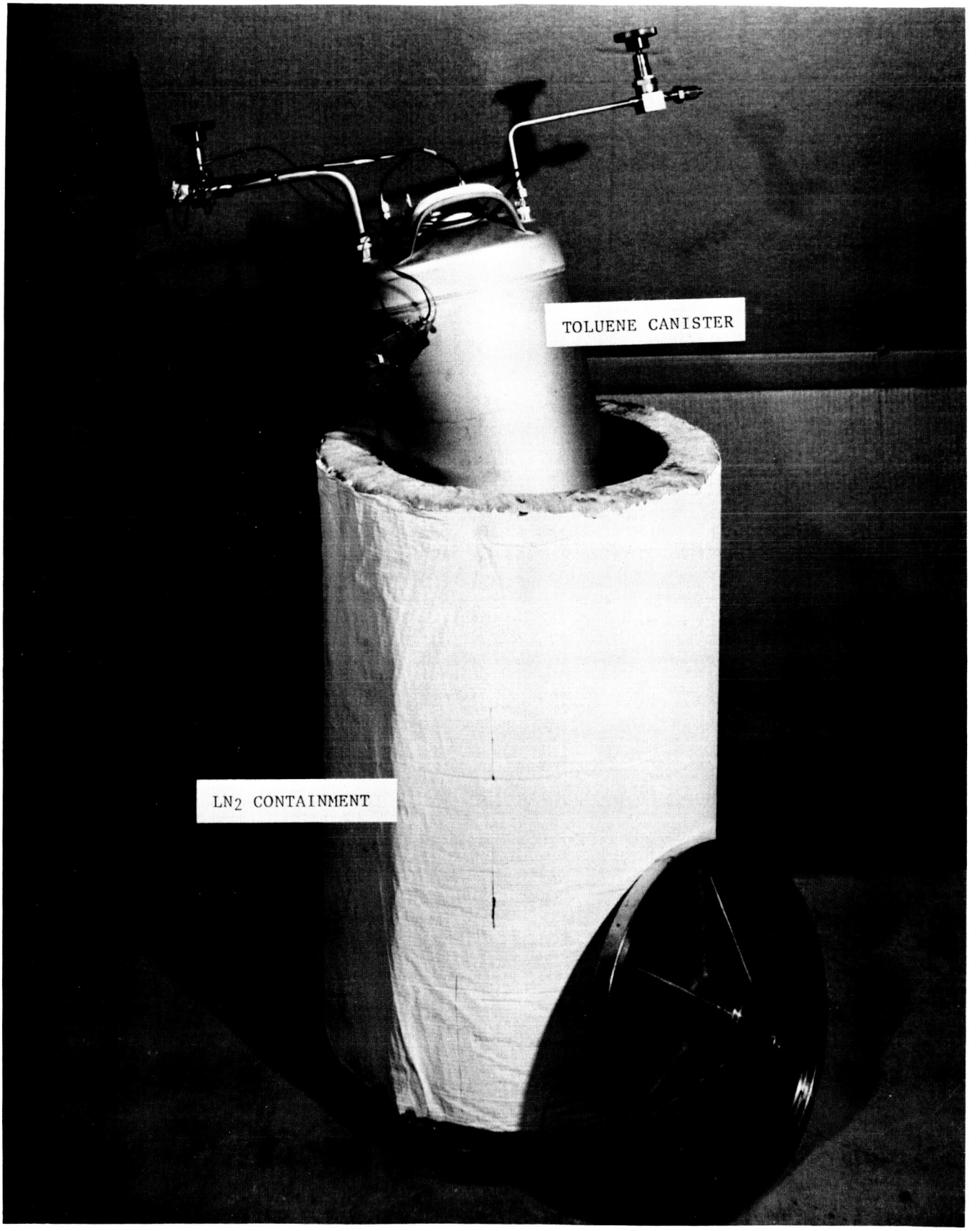


FIGURE 13 TOLUENE PREPARATION CANISTER

cleaning procedure includes a flush, hot vapor degrease, ultrasonic bath and a final rinse. The cleaned part was rinsed with Freon and the effluent was collected for later analysis. A 100 ml sample of the effluent per one square foot of surface area was analyzed for particulate contamination that conformed to NAS 1638, Class 5. A 900 ml sample of the effluent was weighed and slowly evaporated. The remaining nonvolatile residue (NVR) was weighed and could not exceed 10 ppm. All of the loop piece parts were subjected to this rigorous cleaning and inspection procedure. The inspected piece parts were then vacuum baked at a minimum of 200°F and a vacuum level of 10^{-4} torr for at least 12 hours. The vacuum bake procedure removes the cleaning fluid that may remain in small cracks or porosity in the components. The cleaned and baked items were then sealed in clean plastic bags until needed for final assembly.

All of the final assembly of the loop was performed in a controlled environment to prevent contamination of the precision cleaned and bagged piece parts. A temporary down-flow clean room was constructed around the entire perimeter of the test loop. Positive pressure, filtered air provided a particulate and oil-free environment until the loop could be completed, at which time the clean room structure was removed. Deaerated room temperature toluene was loaded into the evacuated test stand. Prior to operating the test stand at design conditions, the fully assembled loop was required to pass the particle count and NVR limits previously defined for the piece parts. The first flush was without heat input from the salt bath heater and identified as a "cold flush". The toluene feed pump circulated the fluid inventory and a sample of fluid from the loop was analyzed. The cold flush particle count and NVR successfully complied with the requirements of Sundstrand CP 14.57-01. The final flush was performed with the salt bath operating at 400°F and was designated a "warm flush". The warm flush particle count and NVR also passed the requirements of CP 14.57-01. Additional gas sampling of the system vapor volume was performed to verify a low oxygen level in the fluid inventory prior to full temperature operation. Gas sampling and analysis is described in Section 5.3.2. The "0" hour data of Table 9 is from the warm flush and shows slightly over 1 sec in the loop. Once the fluid inventory

passed all of these check points, the test loop was considered ready for long-term operation at a 750°F turbine inlet temperature condition.

The completed toluene stability loop is shown in Figure 14. The test stand was assembled and tested in the Sundstrand plant 6 test lab, cell 62. The controls for the cell were located in an adjacent room, cell 61. The salt bath heater assembly is the square box at the far left in the photo. Supercritical toluene vapor exited the salt bath box and was directed to the top of the structure at the far right in the photo. The components from top to bottom are: turbine simulator orifice, turbine simulator heat exchanger, regenerator, condenser, toluene pump and the pulsation damper in the foreground. The Therminol pump is mounted on the platform structure in the lower center of the photo.

Additional details of the construction and operating history are documented and are on file at Sundstrand.

5.0 Data Collection and Analysis

5.1 Operating History

The test loop described in the previous section was designed and constructed with long-term, high reliability, unattended operation as a primary consideration. Continuous operation of the loop was completely automated. Startup of the test loop was performed by manually selecting the desired salt bath temperature, selecting the desired regenerator vapor inlet temperature, selecting the desired condenser temperature, and starting the feed pump. The fluid inventory was continuously circulated through the system by the feed pump with temperatures maintained by automated controls.

Examples of the digital data format and the 8-pen brush recording format are shown in Figures 15 and 16, respectively. The examples shown are for a 750°F test condition. A list of the instrumentation acronyms is shown in Table 2. Figure 17 denotes the location of the instrumentation for this program.

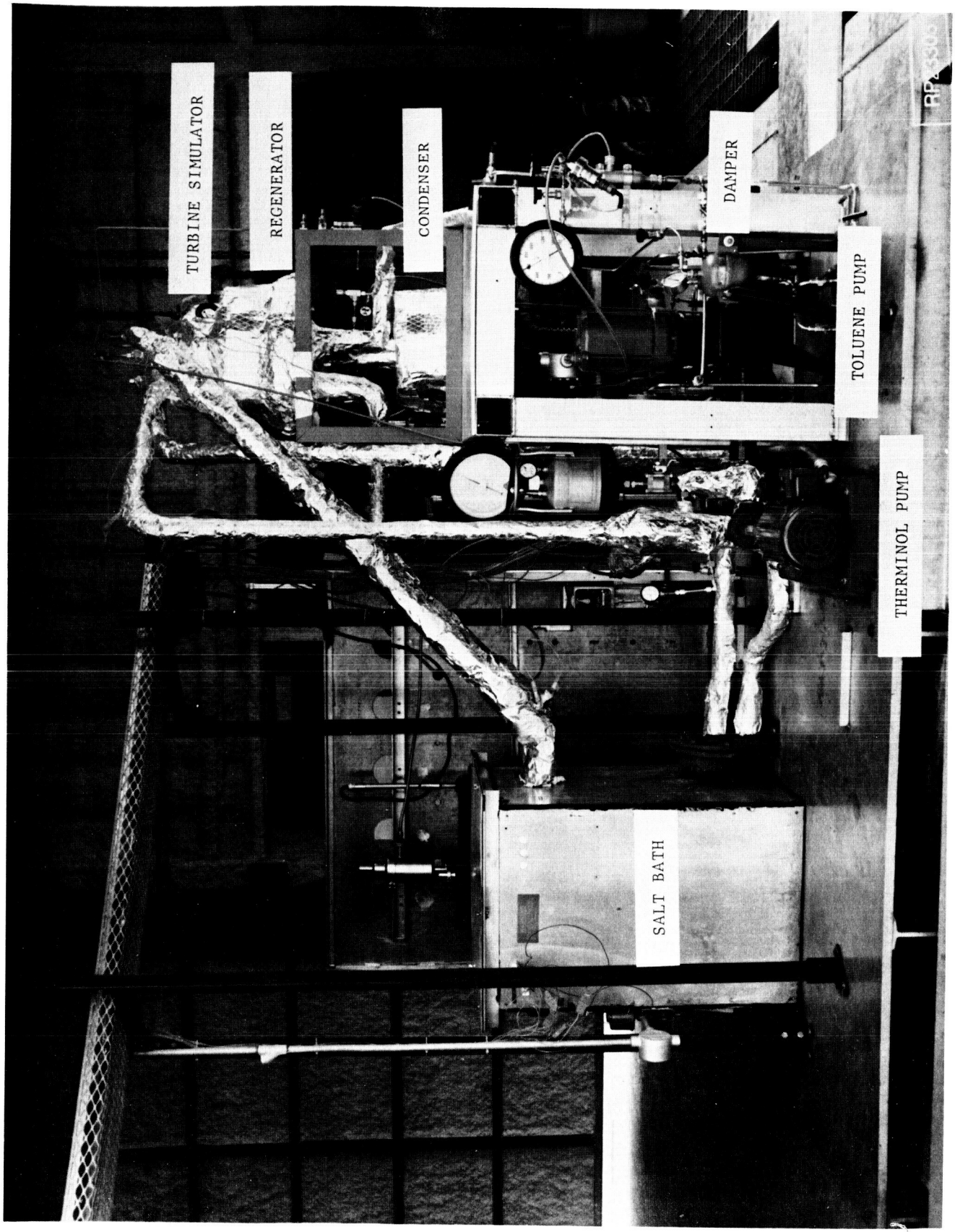


FIGURE 14 COMPLETED LOOP ASSEMBLY

TOLUENE STABILITY LOOP / CELL 62

DATA POINT:		217	218	219	220	221	222		
DATE:		9/19/86	9/19/86	9/19/86	9/19/86	9/19/86	9/19/86		
TIME:		2:41:14	2:46:14	2:51:14	2:56:14	3:1:14	3:6:14	UNITS	LABEL
CHNL	1	750.	748.	750.	749.	749.	749.	DEG F	TVO1
CHNL	2	749.	748.	750.	749.	748.	750.	DEG F	TVO2
CHNL	3	763.	762.	764.	763.	764.	764.	DEG F	TSB1
CHNL	4	770.	767.	772.	769.	771.	771.	DEG F	TV1
CHNL	5	695.	694.	699.	695.	696.	695.	DEG F	TV2
CHNL	6	712.	710.	711.	712.	709.	712.	DEG F	TV3
CHNL	7	729.	729.	729.	729.	729.	729.	DEG F	TV4
CHNL	8	745.	743.	745.	743.	745.	744.	DEG F	TV5
CHNL	9	749.	749.	750.	749.	749.	750.	DEG F	TV6
CHNL	10	1781.	1781.	1781.	1781.	1780.	1782.	DEG F	T10
CHNL	11	303.	303.	303.	302.	303.	303.	DEG F	TRLO
CHNL	12	114.	114.	115.	114.	115.	114.	DEG F	TRLI
CHNL	13	397.	397.	397.	397.	397.	398.	DEG F	TRVI
CHNL	14	249.	249.	248.	249.	252.	248.	DEG F	TRVO
CHNL	15	124.	166.	198.	132.	140.	149.	DEG F	TFO
CHNL	16	119.	120.	120.	120.	121.	117.	DEG F	TCL
CHNL	17	238.	238.	237.	237.	238.	239.	DEG F	TCV
CHNL	18	99.	99.	98.	99.	99.	98.	DEG F	TGS1
CHNL	19	72.	73.	72.	72.	72.	73.	DEG F	TGS2
CHNL	20	190.	190.	191.	191.	191.	190.	DEG F	TOI
CHNL	21	208.	208.	208.	209.	209.	208.	DEG F	TOO
CHNL	22	307.	307.	306.	306.	308.	307.	DEG F	T1
CHNL	23	744.	744.	746.	745.	744.	744.	DEG F	T2
CHNL	24	61.	61.	62.	62.	61.	62.	DEG F	T3
CHNL	25	138.	138.	137.	136.	143.	135.	DEG F	T4
CHNL	26	1780.	1781.	1780.	1780.	1781.	1780.	DEG F	T5
CHNL	27	1780.	1780.	1781.	1780.	1781.	1780.	DEG F	T6
CHNL	28	1780.	1780.	1780.	1781.	1780.	1781.	DEG F	T7
CHNL	29	1780.	1780.	1780.	1781.	1780.	1781.	DEG F	T8
CHNL	30	1781.	1780.	1780.	1780.	1780.	1781.	DEG F	T9
CHNL	31	272.607	272.754	266.748	285.205	277.588	295.166	LB/HR	QT
CHNL	32	0.0	2.1	2.1	2.0	0.0	0.0	GPM	QW
CHNL	33	0.0	0.0	0.0	0.0	0.0	0.0	GPM	QO
CHNL	34	584.	694.	594.	618.	621.	524.	PSIG	PVO
CHNL	35	582.	582.	582.	582.	582.	582.	PSIG	PVI
CHNL	36	598.	604.	604.	598.	603.	599.	PSIG	PPO
CHNL	37	19.0	19.0	18.6	18.8	19.7	18.7	PSIA	PGS

FIGURE 15 DIGITAL DATA FORMAT

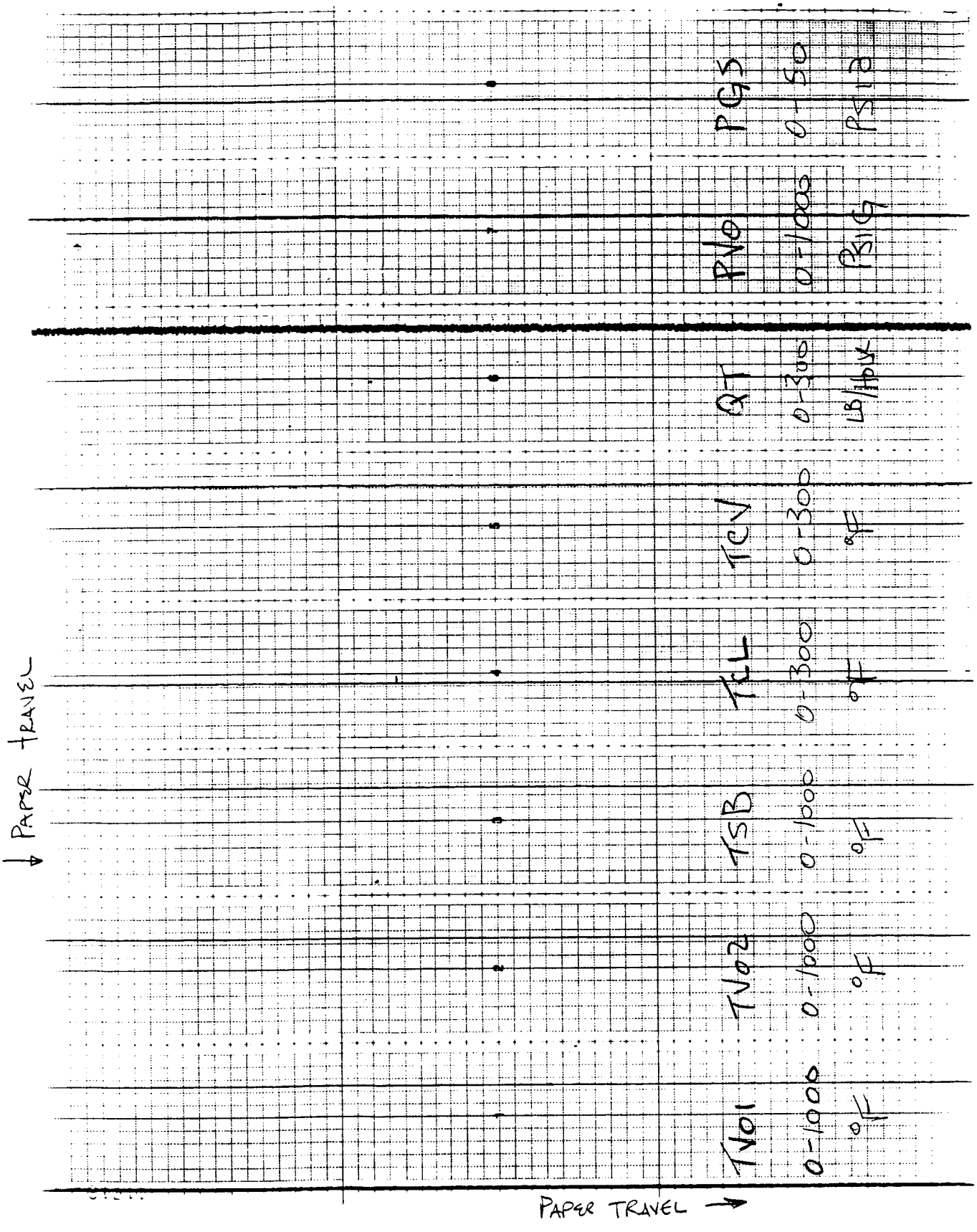


FIGURE 16 BRUSH RECORDER FORMAT

TABLE 2

TOLUENE STABILITY LOOP INSTRUMENTATION LIST

ID	PARAMETER	COMPUTER CHANNEL #	UNITS
TV01	VAPORIZER OUT 1	1	DEGREE-F
TV02	VAPORIZER OUT 2	2	DEGREE-F
TSB1	SALT BATH 1	3	DEGREE-F
TV1	VAPORIZER 1	4	DEGREE-F
TV2	VAPORIZER 2	5	DEGREE-F
TV3	VAPORIZER 3	6	DEGREE-F
TV4	VAPORIZER 4	7	DEGREE-F
TV5	VAPORIZER 5	8	DEGREE-F
TV6	VAPORIZER 6	9	DEGREE-F
T10	- SPARE -	10	DEGREE-F
TRLO	REGEN LIQUID OUT	11	DEGREE-F
TRLI	REGEN LIQUID IN	12	DEGREE-F
TRVI	REGEN VAPOR IN	13	DEGREE-F
TRVO	REGEN VAPOR OUT	14	DEGREE-F
TPO	PUMP OUT	15	DEGREE-F
TCL	COND LIQUID	16	DEGREE-F
TCV	COND VAPOR	17	DEGREE-F
TGS1	GAS SAMPLE 1	18	DEGREE-F
TGS2	GAS SAMPLE 2	19	DEGREE-F
TOI	OIL IN	20	DEGREE-F
TOO	OIL OUT	21	DEGREE-F
T1	VAPORIZER INLET	22	DEGREE-F
T2	VAPORIZER OUTLET	23	DEGREE-F
T3	COND WATER IN	24	DEGREE-F
T4	COND WATER OUT	25	DEGREE-F
T5	- SPARE -	26	DEGREE-F
T6	- SPARE -	27	DEGREE-F
T7	- SPARE -	28	DEGREE-F
T8	- SPARE -	29	DEGREE-F
T9	- SPARE -	30	DEGREE-F
QT	TOLUENE FLOW	31	LBM/HR
QW	CONDENSER WATER FLOW	32	GPM
QO	WATER FLOW - THERMINOL	33	GPM
PVO	PRESS VAPORIZER OUT	34	PSIG
PVI	PRESS VAPORIZER IN	35	PSIG
PPO	PRESSURE PUMP OUT	36	PSIG
PGS	PRESSURE GAS SAMPL	37	PSIA

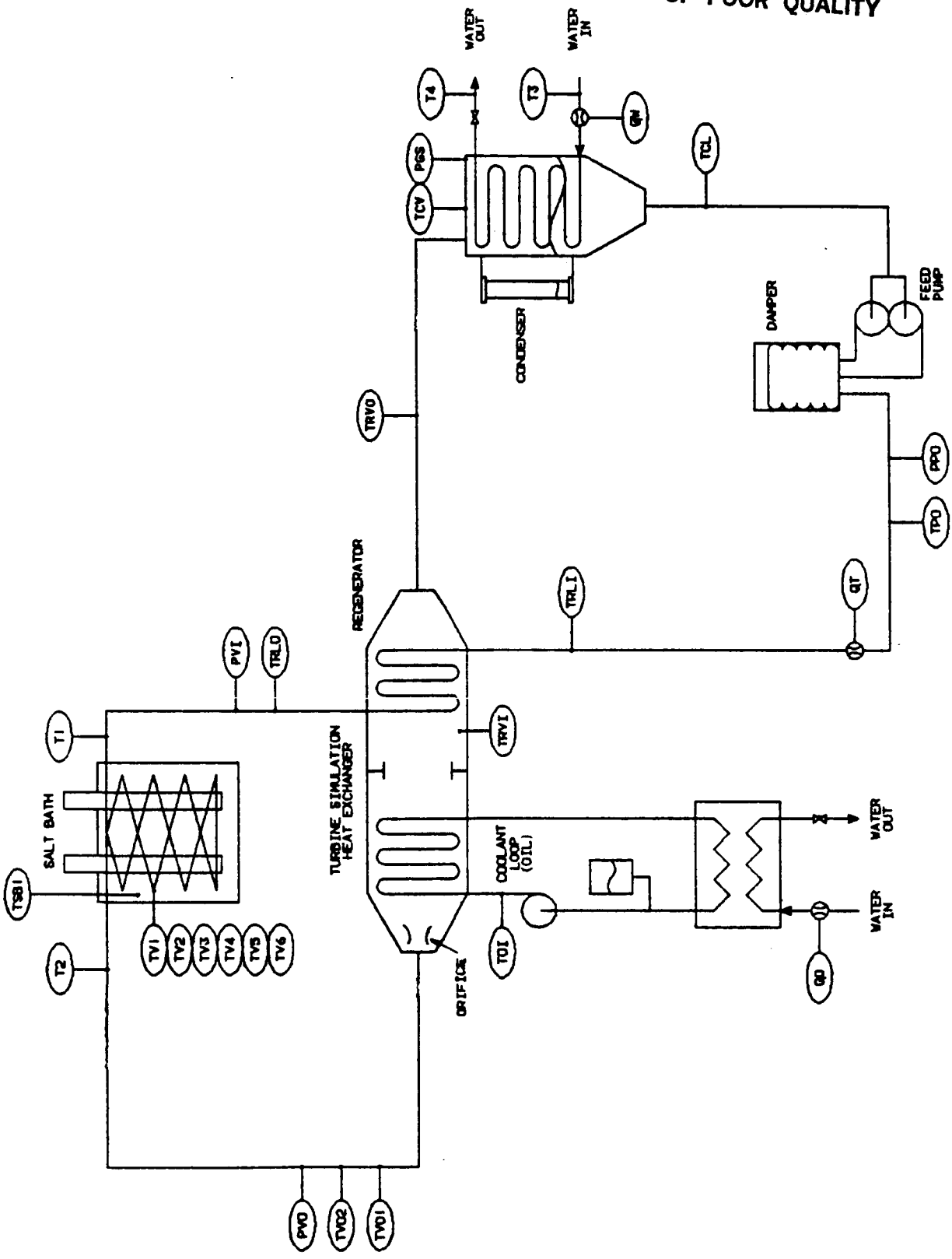


FIGURE 17 TOLUENE STABILITY LOOP INSTRUMENTATION SCHEMATIC

The test loop was monitored by several automated safety circuits that were set at predetermined limits for acceptable operation. In the event of an out-of-limit condition, the safety circuits were activated and the test stand was safely shut down. A shutdown due to exceeding a limit consisted of a cutoff of electrical power to the salt bath heaters and the feed pump motor. Cooling water continued to flow through the heat exchangers to quickly reduce the system temperature. An alarm system was also activated in the event of a shutdown. The alarm alerted the appropriate personnel of a shutdown and the required corrective action was quickly performed to minimize the period of down time. A list of the safety system and the predetermined limits for operation at 750°F are shown in Table 3. Operation at 850°F was performed by overriding the safety circuits, with the operator monitoring the key parameters for safe conditions.

Fluid endurance testing at 750°F turbine inlet temperature was initiated at noon June 16, 1986. Operation of the loop was concluded on November 13, 1986 after 3410 test hours over 3570.6 hours of clock time (a 96% ratio of operating time to clock time). A summary of the operating history of the toluene stability loop is shown in Table 4. The table shows the accumulated test time when a shutdown occurred, the amount of down time, and the cause of the shutdown. The test was concluded with customer concurrence after 3410 test hours. The bulk of the testing was performed at 750°F turbine inlet temperature, with three short excursions to 850°F performed toward the conclusion of the experiment. The loop was returned to 750°F between the 850°F excursions. Table 5 summarizes the test temperature history.

5.2 Liquid Samples

5.2.1 Sampling Procedures

Provisions were made in the loop design to periodically sample the liquid inventory circulating in the active fluid lines. The liquid samples were collected in 40 cc stainless steel sample bottles through manually actuated valves. A schematic of the liquid sample port and the sampling procedure is shown in Figure 18. The procedure in Figure 18 was performed

TABLE 3

SAFETY SHUT DOWN CIRCUIT SET POINTS

Parameter	Nominal Operation	Safety Set Point
Salt Bath Overtemperature	760°F	820°F
Toluene Overtemperature	750°F	770°F
Condenser Overtemperature	250°F	280°F
Toluene Under Flow	270 lb/hour	100 lb/hour
Toluene Leak	0%	20% of lower flammable limit
Salt Bath Nitrogen Pressure	3 inches of water	1 inch of water
Salt Bath Undertemperature (Warning Light Only)	760°F	700°F
Regenerator Vapor Inlet Overtemperature (Warning Light Only)	540°F	600°F

TABLE 4

TOLUENE STABILITY LOOP SHUTDOWNS

Accumulated Test Time (Hours)	Down Time (Hours)	Cause
75	2	Loss of cooling water (Therminol temperature controller failed)
186	0.3	Argon on gas side of damper
208	1.3	Loss of cooling water (facility water turned off - switch to city)
214	0.4	Loss of cooling water (makeup valve opened)
235	1.3	Loss of cooling water (manual valve closed)
279	53.7	Loss of cooling water (line pinched)
281	1.8	Loss of cooling water (makeup valve open)
772	7.1	Loss of cooling water (inlet valve restricted)
815	6.9	Disassembled oil side of feed pump (low toluene flow)
846	13.8	Loss of cooling water (inlet valve restricted)
849	0.8	Replaced salt bath controller fuse
918	2.0	Installed alarm system
1006	3.0	Shorted salt bath heater
1420	29.0	Shorted salt bath heater
1463	1.0	Loose safety relay
1475	0.2	Loose safety relay

TABLE 4 (Continued)

Accumulated Test Time (Hours)	Down Time (Hours)	Cause
1729	13	Open salt bath heater fuses
1737	8	Open salt bath heater fuses
1739	1	Shorted salt bath heater
1755	3	Loss of cooling water (cooling water turned off)
2056	1	Open salt bath heater fuses
2644	10	Planned power outage
3410	--	Open salt bath fuse. With customer concurrence, loop was not restarted.
	160.6 hours	

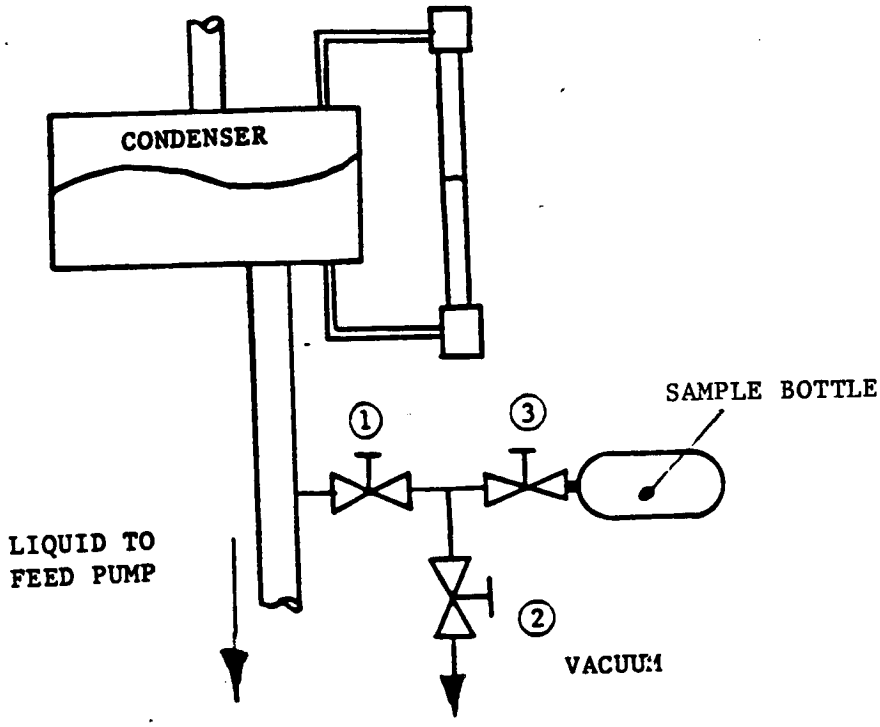
$$\frac{(\text{Operating Time})}{(\text{Clock Time})} = \frac{3410}{(3410 + 160.6)} = 96\%$$

TABLE 5

SUMMARY OF LOOP OPERATION VERSUS TEMPERATURE

Time Frame	Turbine Inlet Temperature	Duration
0-2997	750°F	2997 Hours
2997-3000	850°F	3 Hours
3000-3165	750°F	165 Hours
3165-3168	850°F	3 Hours
3168-3382	750°F	214 Hours
3382-3385	850°F	3 Hours
3385-3410	750°F	25 Hours
		3410 Total Hours

FIGURE 18 LIQUID SAMPLING PROCEDURE



Procedure:

1. All valves normally closed
2. Open (2) and (3) to evacuate sample bottle.
3. Close (2).
4. Remove vacuum source and install Argon supply.
5. Open (2) to fill bottle with Argon.
6. Reinstall vacuum source.
7. Open (2) and (3) to evacuate sample bottle.
8. Close (2).
9. Open (1) to fill bottle with liquid.
10. Close all valves. Remove bottle for analysis.

to prevent air from entering the sample or the active flow circuit. This objective was accomplished by evacuating the interior of the bottle, backfilling with argon, and evacuating again. Extreme care was taken to ensure that the sample bottles were clean prior to drawing a sample from the loop. Each bottle was precision cleaned utilizing Sundstrand specification CP 14.57-01 described in Paragraph 4.2.

5.2.2 Liquid Sample Analysis

Chemical analysis of the liquid samples taken from the toluene stability loop was performed primarily by Sundstrand. Independent verification of the Sundstrand results was performed by Argonne National Laboratories. The Sundstrand analysis was performed with a Varian Model 3700 Gas Chromatograph with a packed SP-2100 silicone column. The Argonne analysis was performed with a Hewlett-Packard 5880A gas chromatograph (GC) equipped with a 30 x 0.32 mm DB5 capillary column (1.0 microfilm). The GC was equipped with a grob-type split/splitless injector, a flame ionization detector, and Level IV Basic programming.

For convenience in reporting and presenting the data, the liquid constituents identified in the liquid toluene samples were grouped into the categories described in Table 6. Elute before benzene are those compounds whose molecular weight is less than benzene. Benzene is listed separately because it is the principal one ring degradation product. Benzaldehyde is separately listed because it is the first oxidation product of degradation indicative of an air in-leak. All other one ring compounds were lumped together. Biphenyl and bibenzyl are listed separately because they are the major degradation products. All other two ring compounds are lumped together. All other compounds of higher molecular weights are listed together as three ring or higher compounds.

The data in Table 7 shows the operating time when the sample was withdrawn and the relative concentration by weight of all the non-toluene products detected. The printed data presented in Table 7 is shown graphically in Figures 19 and 20. Reagent grade toluene was utilized in the loop. Reagent grade (99.9% pure) has a very small but finite contamination

ELUTE BEFORE BENZENE

BENZENE

BENZALDEHYDE

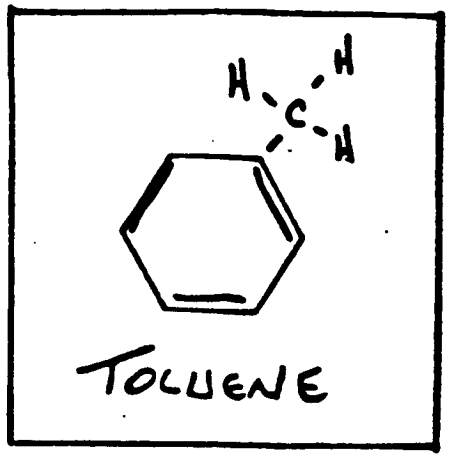
OTHER ONE RING

BIPHENYL

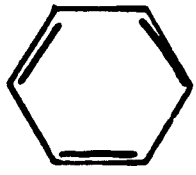
BIBENZYL

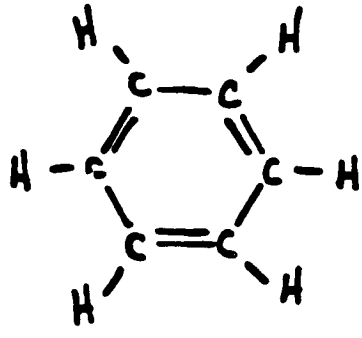
OTHER TWO RING

THREE RING & HIGHER

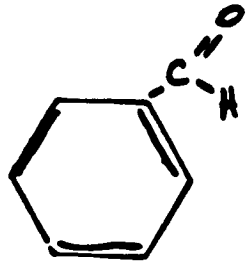


BENZENE

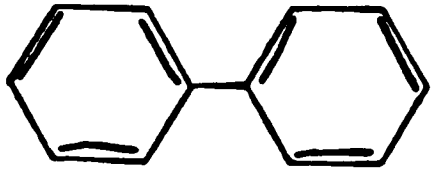




BENZALDEHYDE



BIPHENYL



BIBENZYL

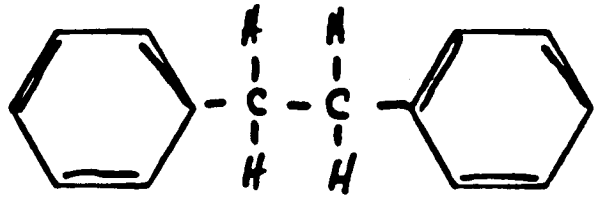


TABLE 7

LIQUID ANALYSIS DATA
WEIGHT %

TIME-HOURS	0	ARGONNE 0	187	512	ARGONNE 541	800	1403	ARGONNE 1403	1713	2001
ELUTE BEFORE BENZENE	0.001	0.016	0.000	0.010	0.020	0.004	0.006	0.018	0.006	0.007
BENZENE	0.001	0.008	0.003	0.005	0.012	0.006	0.014	0.018	0.018	0.018
BENZALDEHYDE	0.000	0.000	0.000	0.001	0.000	0.001	0.002	0.000	0.003	0.003
OTHER ONE RING COMPOUNDS	0.127	0.103	0.123	0.121	0.102	0.119	0.116	0.122	0.115	0.119
BIPHENYL	0.002	0.000	0.013	0.002	0.000	0.013	0.002	0.001	0.007	0.008
BIBENZYL	0.002	0.000	0.009	0.016	0.011	0.020	0.030	0.025	0.034	0.036
OTHER TWO RING COMPOUNDS	0.019	0.000	0.061	0.040	0.011	0.059	0.036	0.038	0.047	0.054
THREE RING OR HIGHER COMPOUNDS	0.011	0.000	0.001	0.010	0.000	0.001	0.002	0.000	0.002	0.009
TOTAL NON-TOLUENE	0.163	0.127	0.210	0.205	0.156	0.223	0.208	0.222	0.231	0.254

NOTE: EACH DATA POINT REPORTED REPRESENTS THE AVERAGE OF THREE READINGS.

TABLE 7 (COMPLETED)

LIQUID ANALYSIS DATA
WEIGHT %

TIME-HOURS	2093	2550	2604	2996	ARGONNE 2996	3000	3164	3168	3381	3385
ELUTE BEFORE BENZENE	0.007	0.006	0.008	0.008	0.000	0.008	0.009	0.009	0.008	0.007
BENZENE	0.019	0.018	0.020	0.019	0.022	0.019	0.021	0.021	0.021	0.020
BENZALDEHYDE	0.004	0.006	0.008	0.004	0.001	0.004	0.005	0.005	0.005	0.005
OTHER ONE RING COMPOUNDS	0.119	0.133	0.119	0.123	0.116	0.118	0.122	0.119	0.121	0.119
BIPHENYL	0.008	0.002	0.005	0.002	0.016	0.003	0.003	0.004	0.002	0.003
BIBENZYL	0.039	0.051	0.048	0.052	0.038	0.054	0.055	0.055	0.061	0.058
OTHER TWO RING COMPOUNDS	0.052	0.062	0.057	0.105	0.050	0.088	0.087	0.081	0.095	0.115
THREE RING OR HIGHER COMPOUNDS	0.002	0.002	0.000	0.003	0.000	0.001	0.001	0.007	0.001	0.001
TOTAL NON-TOLUENE	0.250	0.280	0.265	0.317	0.243	0.296	0.303	0.294	0.313	0.327

EXCURSION #1 850F

EXCURSION #2 850F

EXCURSION #3 850F

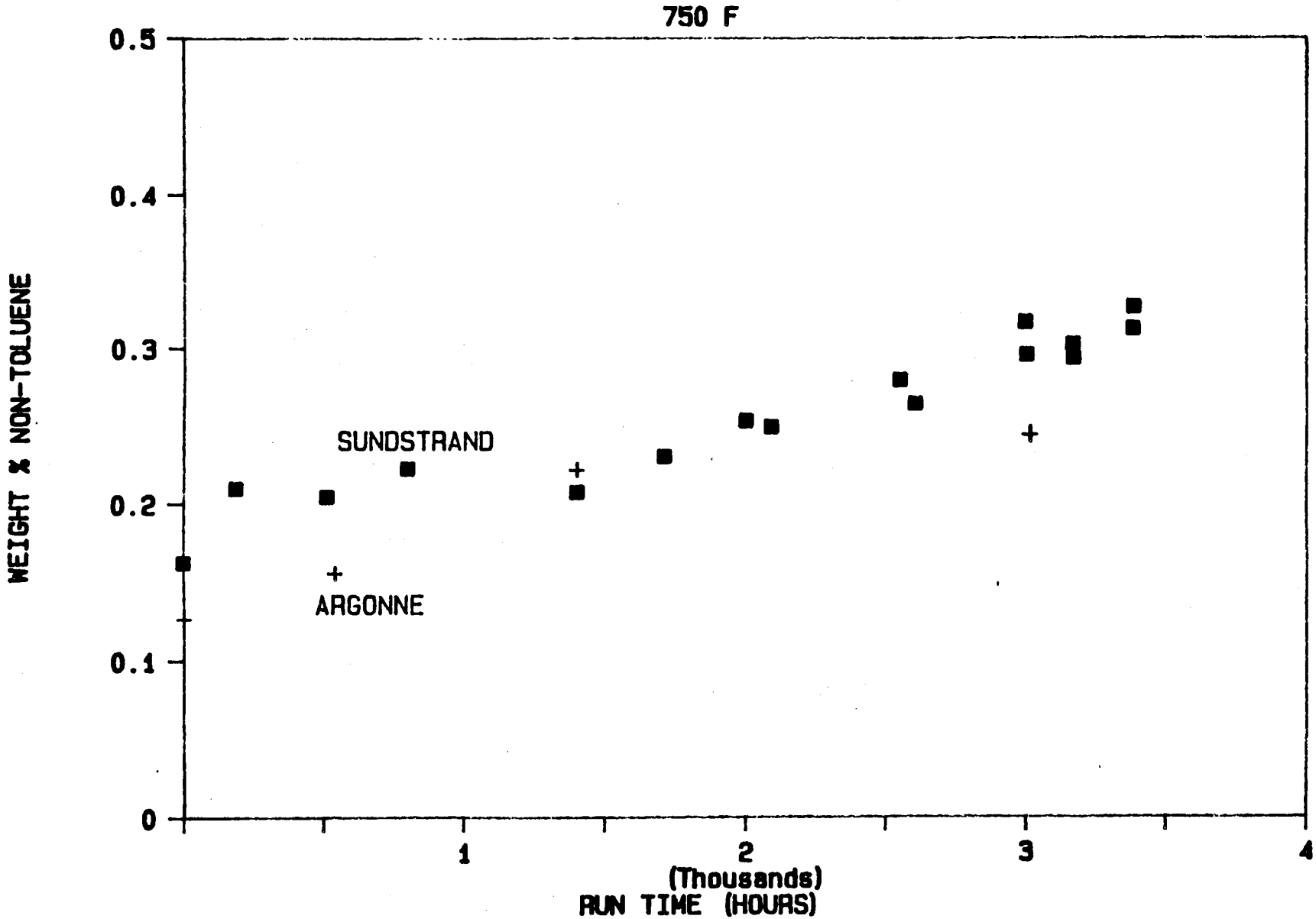


FIGURE 19 COMPARISON OF LABORATORIES LIQUID DEGRADATION

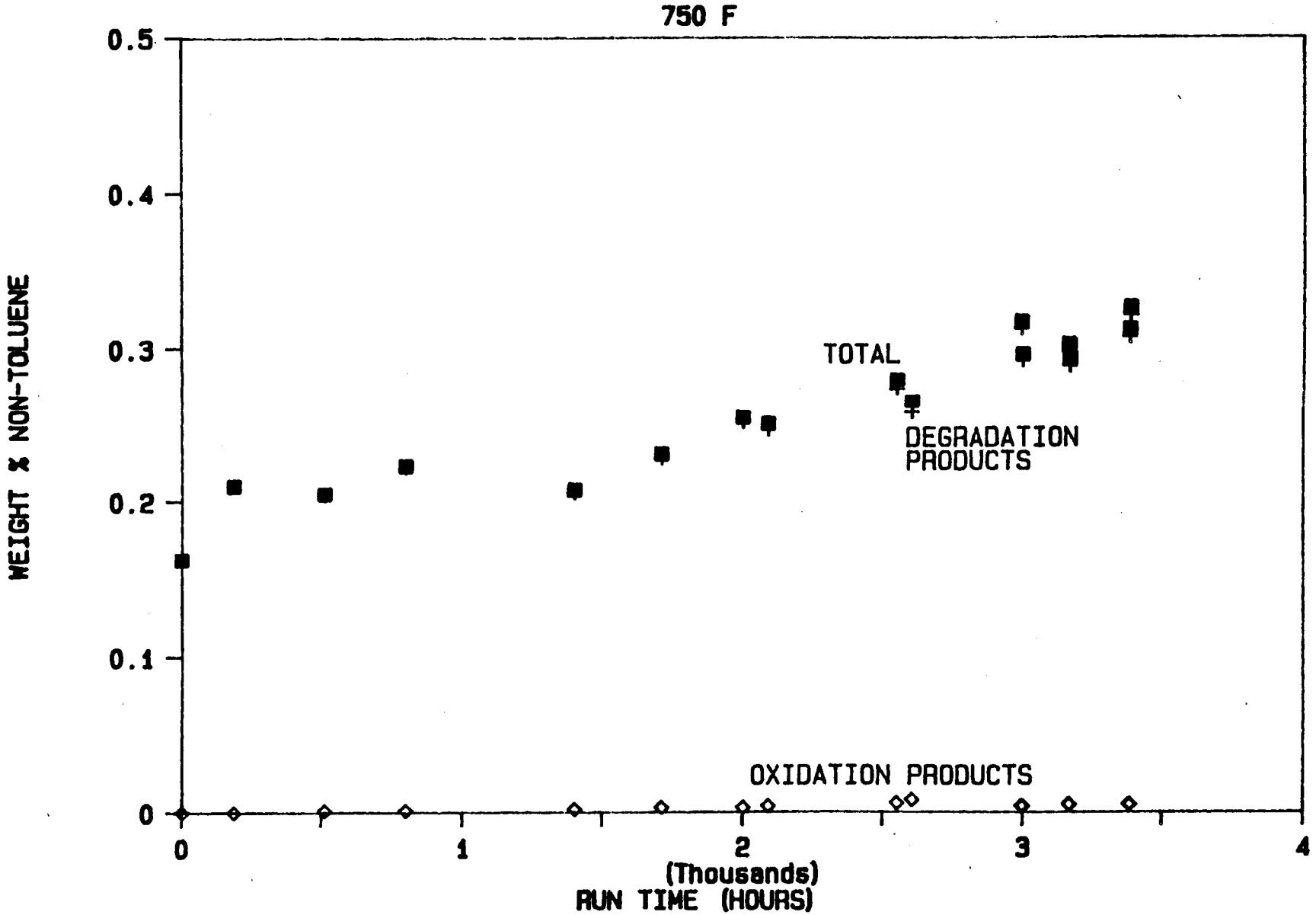


FIGURE 20 LIQUID DEGRADATION CONSTITUENTS

level. The "0" hour data for degradation is indicative of the fresh fluid contamination. Figure 19 indicates the accumulation of non-toluene products with respect to time and verifies the good agreement between the two different analytical laboratories. Figure 20 shows the total liquid non-toluene products, the liquid degradation products only, and liquid oxidation products (benzaldehyde). As this graph shows, the liquid oxidation products constituted a very small percentage of the total non-toluene products and therefore in-leakage contamination was not a significant contributor to the measured degradation.

A small accumulation of product near the expected elution time of benzaldehyde has been observed. The peak is assumed to be benzaldehyde. Refer to Table 6. Benzaldehyde is the first expected liquid product of oxidation. No other liquid products of oxidation were detected. An additional GC analysis technique was performed on the 2001 hour sample that was specifically looking for benzoic acid. Benzoic acid is an expected product of toluene oxidation. Benzaldehyde is of lower stability than toluene and is rapidly oxidized. Benzoic acid is the first oxidation product of benzaldehyde. The technique employed was sensitive to 5 ppm. No benzoic acid was detected by the analysis. This indicates that the product assumed to be benzaldehyde may not have been and, further, that no oxidation products may have been present.

Upon completion of the endurance test at 750°F, several short excursions to 850°F were performed and analyzed. The objective of the excursions was to determine the tolerance of toluene to short periods of over-temperature exposure. Three excursions to 850°F for three hours each were performed. Three hours was chosen to simulate two complete orbits of the Space Station (90 minutes per orbit). Liquid and noncondensible gas samples were taken before and after the period of 850°F operation.

The 2996 hours gas and liquid samples were the completion of the test period at 750°F. These samples were also the bench marks required to determine the effects of a three hour excursion to 850°F. Immediately after the 2996 hour samples, the salt bath temperature was increased to 850°F. For this first excursion to 850°F, the "ramp up" period required

approximately 30 minutes. This period was spent determining which safety shutdown relays needed to be removed from the active system. The subsequent ramp up periods, and all of the ramp down periods, were on the order of ten minutes. The 850°F temperature was maintained for a total of 3 hours. At the completion of the excursion, a liquid sample was taken at 3000 hours (immediately after returning to 750°F). Two additional excursions to 850°F were performed, with both pre- and post- excursion liquid samples taken from the system.

The pre- and post- excursion analysis of the liquid data does not show any noticeable change or trend. The variation in measurement of the data is within the range of scatter. This is as expected based on capsule test data. For an 850°F system, the predicted liquid degradation rate is 1.7×10^{-4} wt%/hour. For a three hour excursion, this would be a total of 0.0005 wt%. This level of change would be undetectable in the liquid sample.

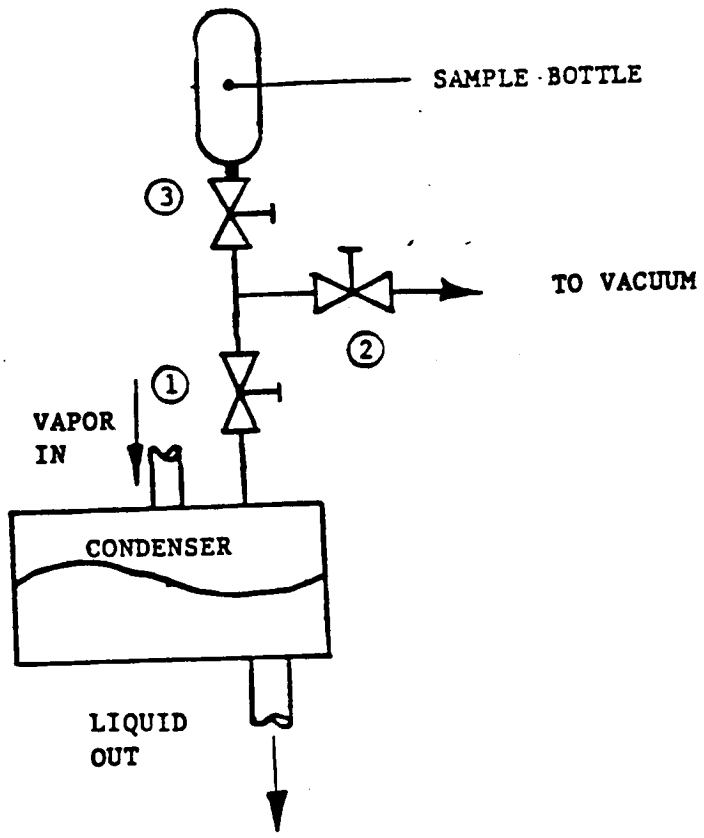
A change in the visual appearance of the fluid is typically among the first signs of degradation. Fresh toluene is clear. Slightly degraded fluid will have a yellow tint. All of the samples from the stability loop were crystal clear.

5.3 Noncondensible Gas Samples

5.3.1 Sampling Procedure

Provisions were made in the loop design to periodically sample the accumulated noncondensible (NC) gases in the system. The gas samples were collected in both 125 scc and 250 scc glass bottles through manually actuated valves. A schematic of the NC gas sample station and the gas sampling procedure is shown in Figure 21. The procedure utilizes evacuation, backfilling with an inert gas, and evacuating as described for the liquid samples. The NC gas sample bottles were also cleaned per Sundstrand Specification CP 14.57-01.

FIGURE 21 NC GAS SAMPLING PROCEDURE



NC gas will accumulate in the top of cool sample bottle. Toluene condensed in bottle will collect in bottom of bottle and some will drip back.

Procedure:

1. All valves normally closed.
2. Open (2) and (3) to evacuate sample bottle.
3. Close (2).
4. Remove vacuum source and install Argon supply.
5. Open (2) to fill bottle with Argon.
6. Reinstall vacuum lines.
7. Repeat (2) and (3).
8. Open valve (1), continue until condensation in the bottle stops.
9. Close valve (3).
10. Close valve (1).
11. Remove sample bottle.

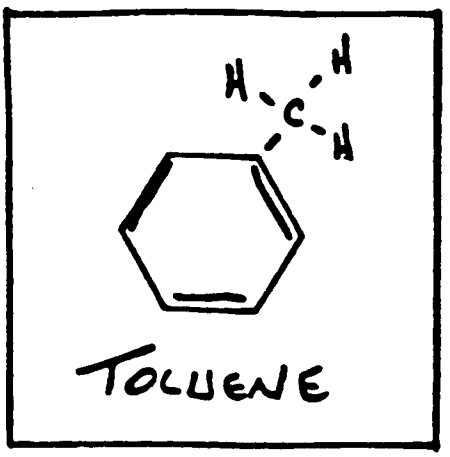
The vapor sample was taken from the top of the condenser vapor volume. A purged and evacuated sample bottle was mounted vertically from the top of the condenser housing. The sample bottle interior was slowly exposed to the 250°F vapor in the condenser. As the vapor entered the room temperature sample bottle, it condensed on the cool walls of the bottle and created a vacuum that drew more vapor into the sample bottle. The vapor that entered the sample bottle carried with it small amounts of the noncondensible gases. As the toluene vapor condensed, the noncondensible gases remained and accumulated in the top section of the bottle. The condensate collected in the bottom of the bottle. The accumulation of noncondensible gases prevents the condensation process to occur in the top section of the bottle; this interface was very distinct. In the noncondensible occluded portion of the bottle the surface approached ambient temperature. In the active condensing section, the temperature approached the condenser saturation temperature of >200°F. This method of collecting the noncondensible gases resulted in a concentrated sample of gas for chemical analysis. The concentrated sample of gas was pressurized to ambient pressure by carefully backfilling the sample bottle with mercury. The absolute volume of the noncondensible gases at ambient temperature and pressure was then measured and recorded.

5.3.2 NC Gas Sample Analysis

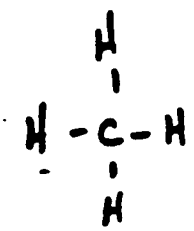
Chemical analysis of the noncondensible gas samples taken from the toluene stability loop was performed by Sundstrand. The Sundstrand analysis was performed with a Varian Model 3700 Gas Chromatograph with molecular sieve and silica gel packed columns.

A summary of noncondensible gases identified by the chemical analysis technique is shown in Table 8. Amounts of each constituent detected are shown in Table 9. Figures 22, 23 and 24 are graphical representations of the tabular data presented in Table 9. The gas constituents were categorized as (1) toluene degradation products, (2) inert gases, and (3) oxygenated products. Hydrogen, methane, ethane, and propane are toluene pyrolytic degradation products. The identified products of degradation were as expected from capsule tests. The remaining gases were

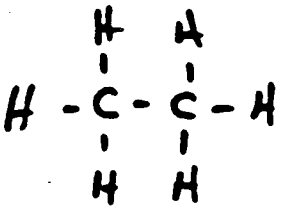
HYDROGEN (H2)
METHANE (CH4)
ETHANE (C2H6)
PROPANE (C3H8)
NITROGEN (N2)
CARBON MONOXIDE (CO)
CARBON DIOXIDE (CO2)



METHANE



ETHANE



PROPANE

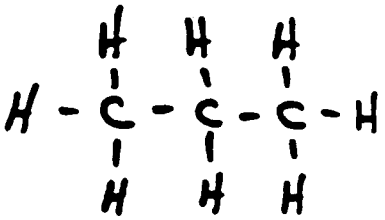


TABLE 9

NC GAS ANALYSIS DATA

		0 HOURS*	20 HOURS*	45 HOURS*	165 HOURS*	234 HOURS*
TOLUENE DEGRADATION PRODUCTS (% BY WEIGHT)						
HYDROGEN	(H_2)	9%	66%	82%	70%	55%
METHANE	(CH_4)	0%	4%	1.5%	3%	12%
ETHANE	(C_2H_6)	0%	0%	0%	0%	0%
PROPANE	(C_3H_8)	0%	0%	0%	0%	0%
INERT GASES (%)						
ARGON	(AR)	14%	14%	6.5%	3%	4%
NITROGEN	(N_2)	64%	14%	7%	12%	19%
OXYGENATED PRODUCTS (%)						
OXYGEN	(O_2)	13%	2%	0%	0%	0%
CARBON MONOXIDE	(CO)	0%	0%	3%	6.5%	9.5%
CARBON DIOXIDE	(CO_2)	0%	0%	0%	0%	0%
TOTAL VOLUME (SCC)		8.9	7.3	21.5	42.5	39

* 250 SCC BOTTLE. ALL OTHERS WERE 125 SCC BOTTLES.

NOTES: THE MEASURED PERCENTAGES FOR EACH SAMPLE SHOULD SUM TO 100%. DUE TO VARIOUS INACCURACIES IN THE GC ANALYSIS, SOME SAMPLES HAVE SMALL DEVIATIONS. THE TOTAL VOLUME WERE DIRECTLY MEASURED BY BACKFILLING THE CAPSULES WITH MERCURY TO ROOM PRESSURE AND ALLOWING THERMAL EQUILIBRIUM TO BE REACHED. THE RESULTANT BUBBLE WAS MEASURED BY LIQUID DISPLACEMENT.

TABLE 9 (continued)

NC GAS ANALYSIS DATA

		296 HOURS	440 HOURS	512 HOURS	631-1 HOURS	631-2 HOURS	800 HOURS
TOLUENE DEGRADATION PRODUCTS (% BY WEIGHT)							
HYDROGEN	(H_2)	61%	41%	41%	24%	34.5%	31.4%
METHANE	(CH_4)	6%	9.5%	8.6%	11.8%	15.2%	10.1%
ETHANE	(C_2H_6)	0%	0.10%	0.12%	0.15%	0.20%	0.15%
PROPANE	(C_3H_8)	0%	0.02%	0.05%	0.06%	0.07%	0.01%
INERT GASES (%)							
ARGON	(AR)	2%	1.5%	1.0%	1.0%	1.0%	2.8%
NITROGEN	(N_2)	20%	29%	28.5%	38%	28%	40%
OXYGENATED PRODUCTS (%)							
OXYGEN	(O_2)	0%	0%	0%	0%	0%	0%
CARBON MONOXIDE	(CO)	8%	12.5%	11.4%	15.5%	13.5%	11.4%
CARBON MONOXIDE	(CO_2)	1%	1.5%	1.2%	1.4%	2%	1.3%
TOTAL VOLUME (SCC)		19	17	13	11.4	6.7	17.2

TABLE 9 (continued)

NC GAS ANALYSIS DATA

		938 HOURS	1071 HOURS	1446 HOURS	1713 HOURS	2001 HOURS	2168 HOURS
TOLUENE DEGRADATION PRODUCTS (% BY WEIGHT)							
HYDROGEN	(H_2)	24.1%	19.5%	10.8%	7.4%	7.5%	7.2%
METHANE	(CH_4)	17.5%	14.0%	17.7%	20.1%	25.5%	22.2%
ETHANE	(C_2H_6)	0.2%	0.2%	0.23%	0.2%	0.37%	0.3%
PROPANE	(C_3H_8)	0.0%	0.06%	0.08%	0.08%	0.15%	0.1%
INERT GASES (%)							
ARGON	(AR)	1.0%	1.0%	1.0%	1%	1%	1.6%
NITROGEN	(N_2)	35.0%	40.0%	51.0%	57%	50%	52.3%
OXYGENATED PRODUCTS (%)							
OXYGEN	(O_2)	0%	0%	0%	0%	0%	0%
CARBON MONOXIDE	(CO)	15.9%	16%	14.5%	13.3%	11.5%	10.9%
CARBON DIOXIDE	(CO_2)	1.7	1.4%	1.6%	2.5%	2.5%	2.0%
TOTAL VOLUME (SCC)		37.4	18.8	21.8	7.2	44.4	30.0

TABLE 9 (continued)

NC GAS ANALYSIS DATA

		2550 HOURS	2996 HOURS		3164 HOURS		3189 HOURS
TOLUENE DEGRADATION PRODUCTS (% BY WEIGHT)							
HYDROGEN	(H_2)	5.4%	5.2%	EXCURSION	-	EXCURSION	-
METHANE	(CH_4)	23.0%	23.3%		-		-
ETHANE	(C_2H_6)	0.3%	0.35%		-		-
PROPANE	(C_3H_8)	0.08%	0.05%		-		-
INERT GASES (%)							
ARGON	(AR)	1%	1%	#1	38%	#2	67%
NITROGEN	(N_2)	54.0%	59%		-		-
OXYGENATED PRODUCTS (%)				850F		850F	
OXYGEN	(O_2)	0%	0%		-		-
CARBON MONOXIDE	(CO)	9.5%	8.2%		-		-
CARBON DIOXIDE	(CO_2)	2.0%	2.1%		-		-
TOTAL VOLUME (SCC)		32.4%	40.4%	PULSATION DAMPER DIAPHRAGM FAILURE	LARGE		LARGE

TABLE 9 (continued)

NC GAS ANALYSIS DATA

		3212 HOURS*	3335 HOURS	3356 HOURS	3362 HOURS	3380 HOURS	3381 HOURS
TOLUENE DEGRADATION PRODUCTS (% BY WEIGHT)							
HYDROGEN	(H_2)	-	-	-	-	-	8.4%
METHANE	(CH_4)	-	-	-	-	-	6.6%
EHTANE	(C_2H_6)	-	-	-	-	-	0.15%
PROPANE	(C_3H_8)	-	-	-	-	-	0.05%
INERT GASES (%)							
ARGON	(AR)	65%	-	61%	-	-	32.0%
NITROGEN	(N_2)	-	-	-	-	-	46.0%
OXYGENATED PRODUCTS (%)							
OXYGEN	(O_2)	-	-	-	-	-	6.0%
CARBON MONOXIDE	(CO)	-	-	-	-	-	0.96%
CARBON DIOXIDE	(CO_2)	-	-	-	-	-	0.76%
TOTAL VOLUME (SCC)		LARGE	LARGE	LARGE	LARGE	SMALL	2.5

* 250 SCC BOTTLE. ALL OTHERS WERE 125 SCC BOTTLES.

TABLE 9 (completed)

NC GAS ANALYSIS DATA

EXCURSION #3 850F

		3400 HOURS
TOLUENE DEGRADATION PRODUCTS (% BY WEIGHT)		
HYDROGEN	(H_2)	12.7%
METHANE	(CH_4)	20.0%
ETHANE	(C_2H_6)	0.54%
PROPANE	(C_3H_8)	0.10%
INERT GASES (%)		
ARGON	(AR)	44.0%
NITROGEN	(N_2)	14.0%
OXYGENATED PRODUCTS (%)		
OXYGEN	(O_2)	0%
CARBON MONOXIDE	(CO)	2.1%
CARBON DIOXIDE	(CO_2)	2.6%
TOTAL VOLUME (SCC)		60.0

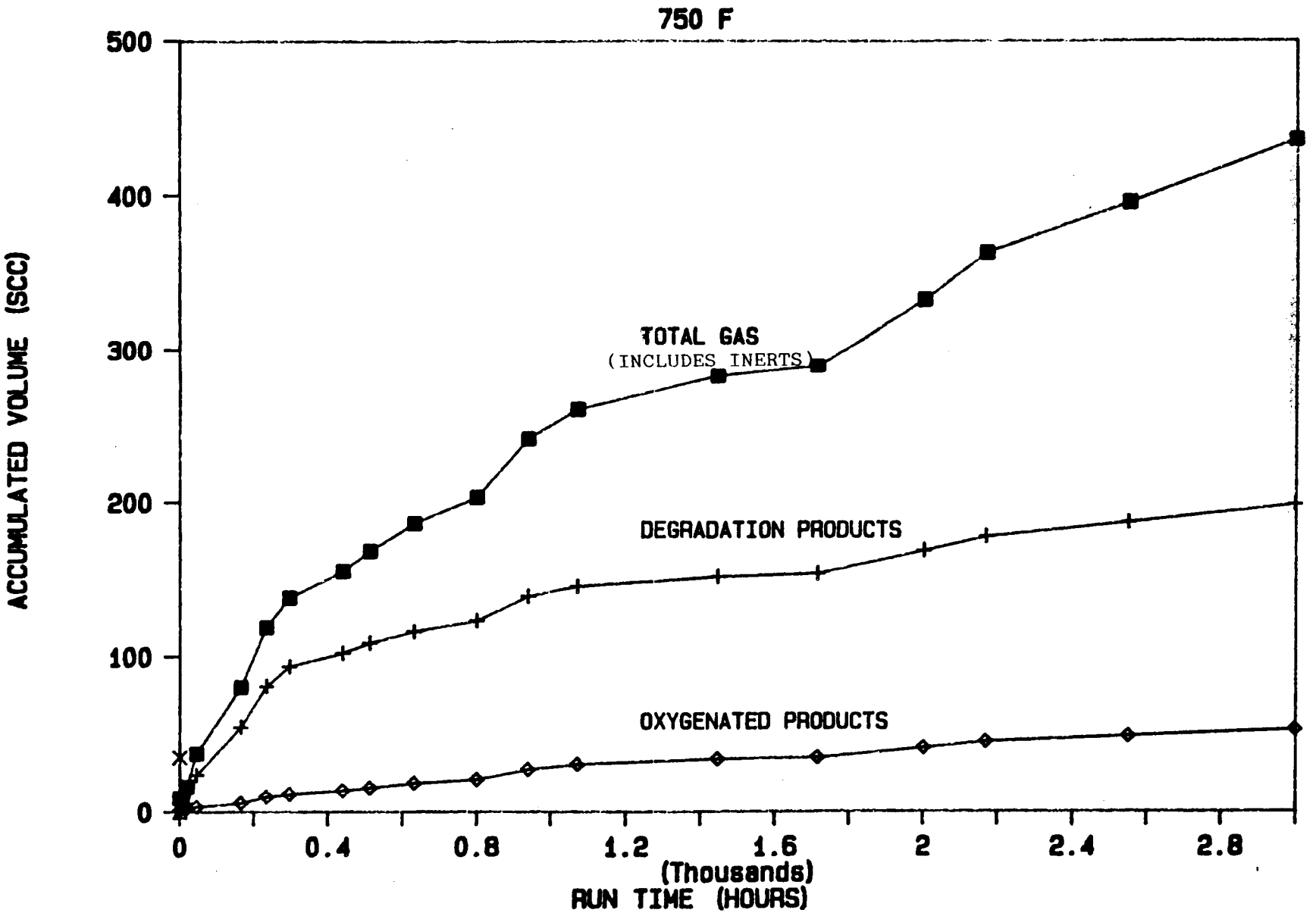


FIGURE 22 COLLECTED GAS BY CATEGORY

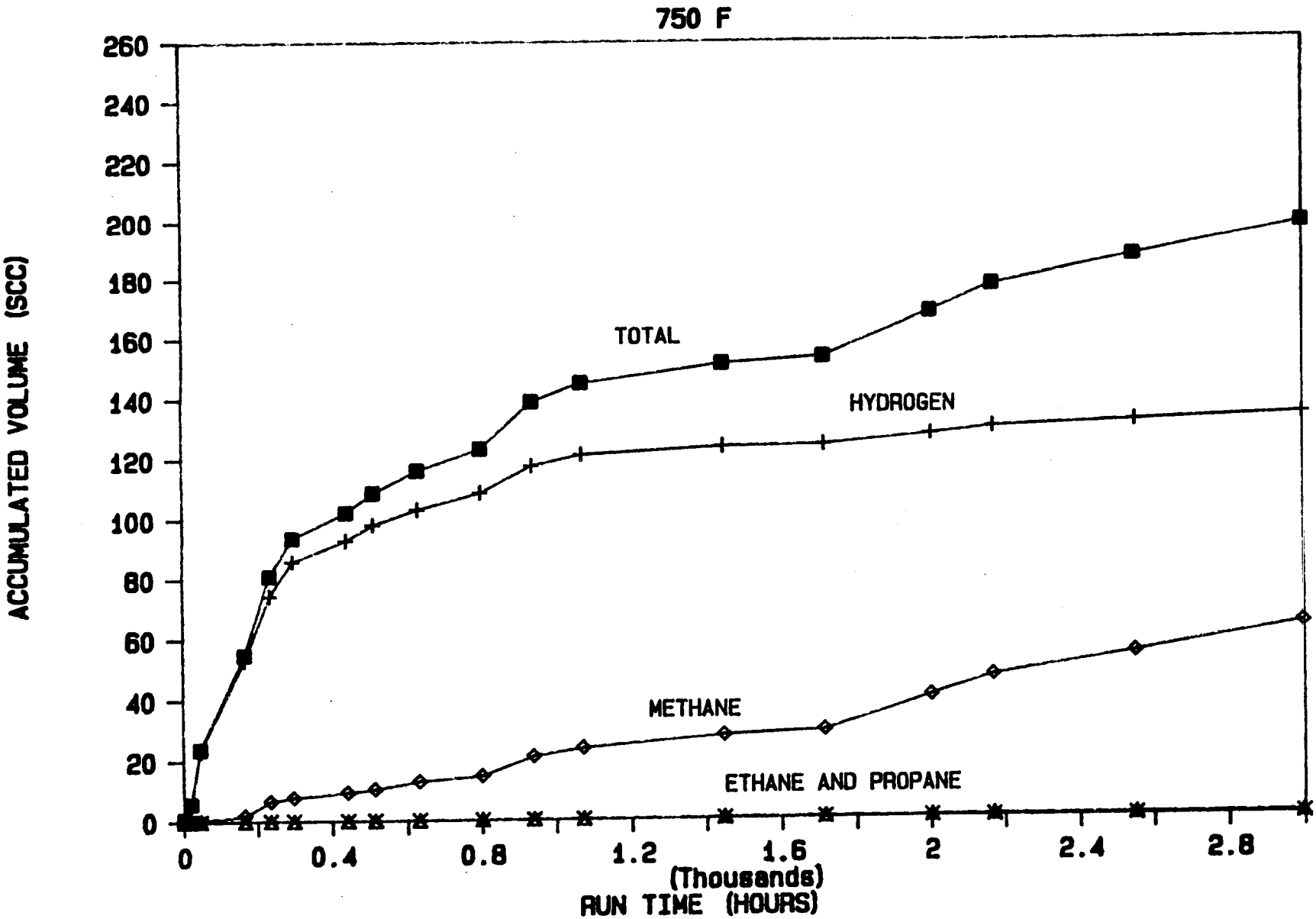


FIGURE 23 GASEOUS DEGRADATION PRODUCTS

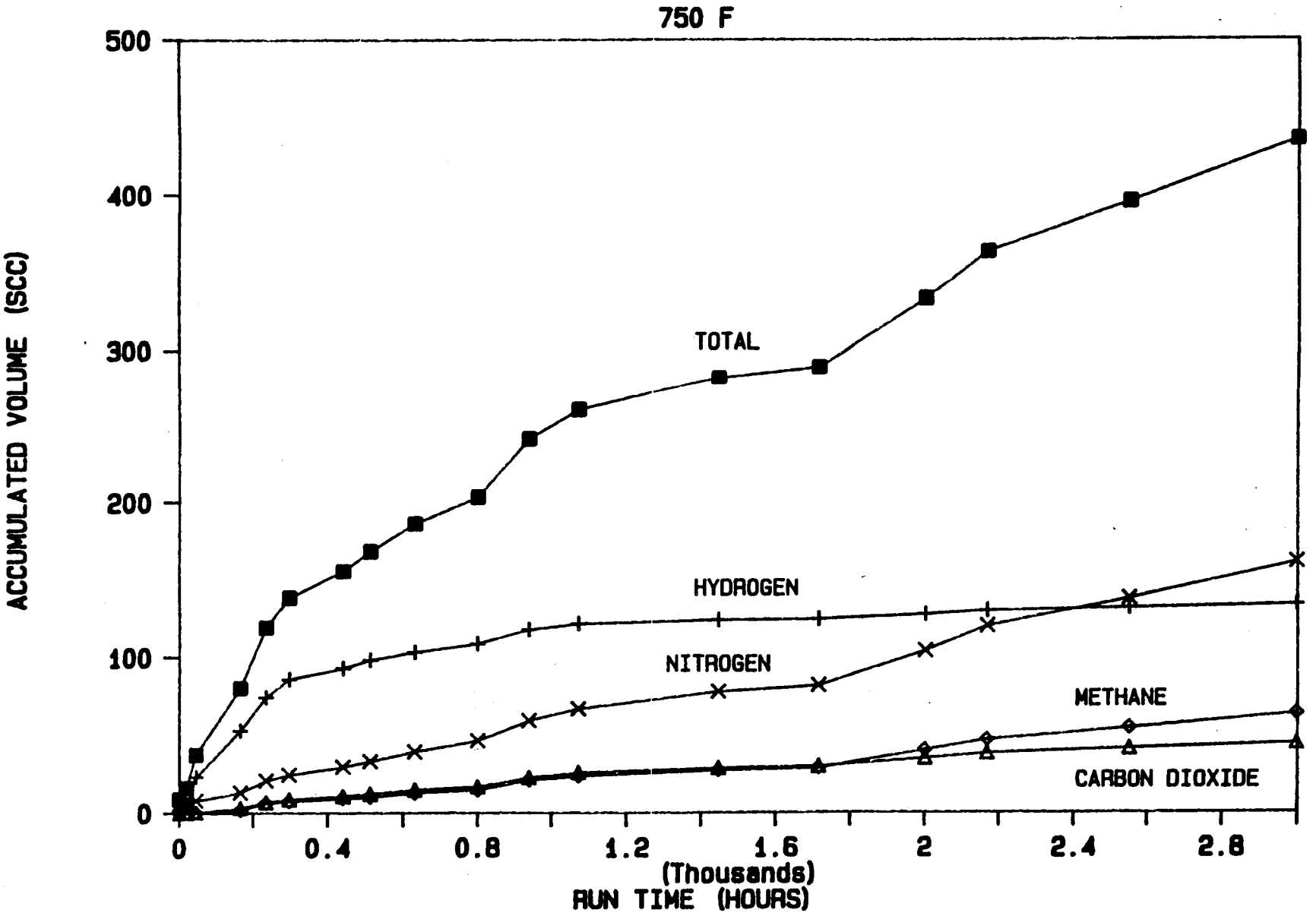


FIGURE 24 COLLECTED GAS

contaminants, probably due to a small air leak. The presence of contaminants does not influence the generation rate of pyrolytic products which can be easily identified. However, because oxidation products form at a much more rapid rate than the pyrolysis, the apparent degradation is much higher. Because no oxidation products were found in the liquid phase, it is probable the air leak was occurring in the cold side of the loop and ingested oxygen was not refluxed through the heater. Therefore, the in-leak represented a slight increase in the total pressure rise rate and a slightly more frequent sampling rate to remove the accumulation. The total amount of oxygenated product present in the gas and liquid samples (O_2, CO_2, CO, benzaldehyde) comprised only 2% by weight of the non-toluene products measured. Based on the low level of oxygenated degradation products, the small air volume detected in the sample results did not affect the validity of the final stability loop results.

The 2996 hours gas and liquid samples were the completion of the test period at 750°F. These samples were also the bench marks required to determine the effects of a three hour excursion to 850°F. Immediately after the 2996 hour samples, the salt bath temperature was increased to 850°F. The 850°F temperature was maintained for a total of 3 hours.

A post-excursion gas sample was taken at 3164 hours. The 3164 hour gas sample was performed immediately prior to the second excursion to 850°F. The excursion was performed prior to analyzing the 3164 hour gas sample. Analysis of this sample discovered a dramatic increase in the amount of Argon in the system. The source of this Argon could be isolated to two potential sources: residual gas left in the sample bottle during the purging and evaluating procedure, or from the gas side of the pulsation damper. A repeat gas sample was performed at 3189 hours, taking particular care to verify that no Argon remained in the sample bottle due to purging and evacuating. This sample contained 67% Argon and the bubble volume was very large. By process of elimination, the pulsation damper was identified as the source of the excess Argon. The pulsation damper was valved out of the active system. The pump discharge flow then

bypassed the pulsation damper. The loop operated in this condition for the remaining duration of the experiment.

Repeated gas sampling from 3164 hours to 3380 hours was performed to remove the Argon from the loop. See Table 9. At 3381 hours, a very small (2.5scc) bubble was obtained. A small bubble indicates the argon was removed, and the loop was considered ready for the third, and final, excursion to 850°F for three hours.

The total gas data collected over the final 850°F excursion was 60 scc. Toluene degradation products accounted for 20 scc of the total 60 scc collected. This results in a rate of formation of 6.7 scc/hour. The predicted rate of gas formation, based on capsule test data, for an 850°F test is 6.3 scc/hour (See Figure 25). Meaningful gas data was not obtained from the first two excursions due to the Argon introduced from the ruptured diaphragm.

5.4 Statistical Analysis of Sample Constituents

A statistical analysis of the gas and liquid chemical constituent formation rates was performed. The gas analysis was performed with the set of data between 440 hours and 2550 hours, inclusive. The initial test period from 0 hours to 440 hours was not included in the least squares curve fit analysis of the gas data. The 0 hour to 187 hour test period was not included in the liquid analysis. These initial periods were not included in the analysis because the rate of degradation was influenced by factors other than pyrolytic degradation. This initial period is influenced by several factors: residual contamination in the loop, residual contamination in the fluid used to charge the loop, conditioning of the fluid, interaction of the fluid with surface impurities in the containment materials, etc. Based on past experience, it is most likely this initial high rate is resultant from the pyrolytic degradation of the small contamination in the reagent toluene used to charge the loop. This contamination (usually other one ring compounds, refer to Table 7 "0" hours) has lower thermal stability and is rapidly degraded away. Once

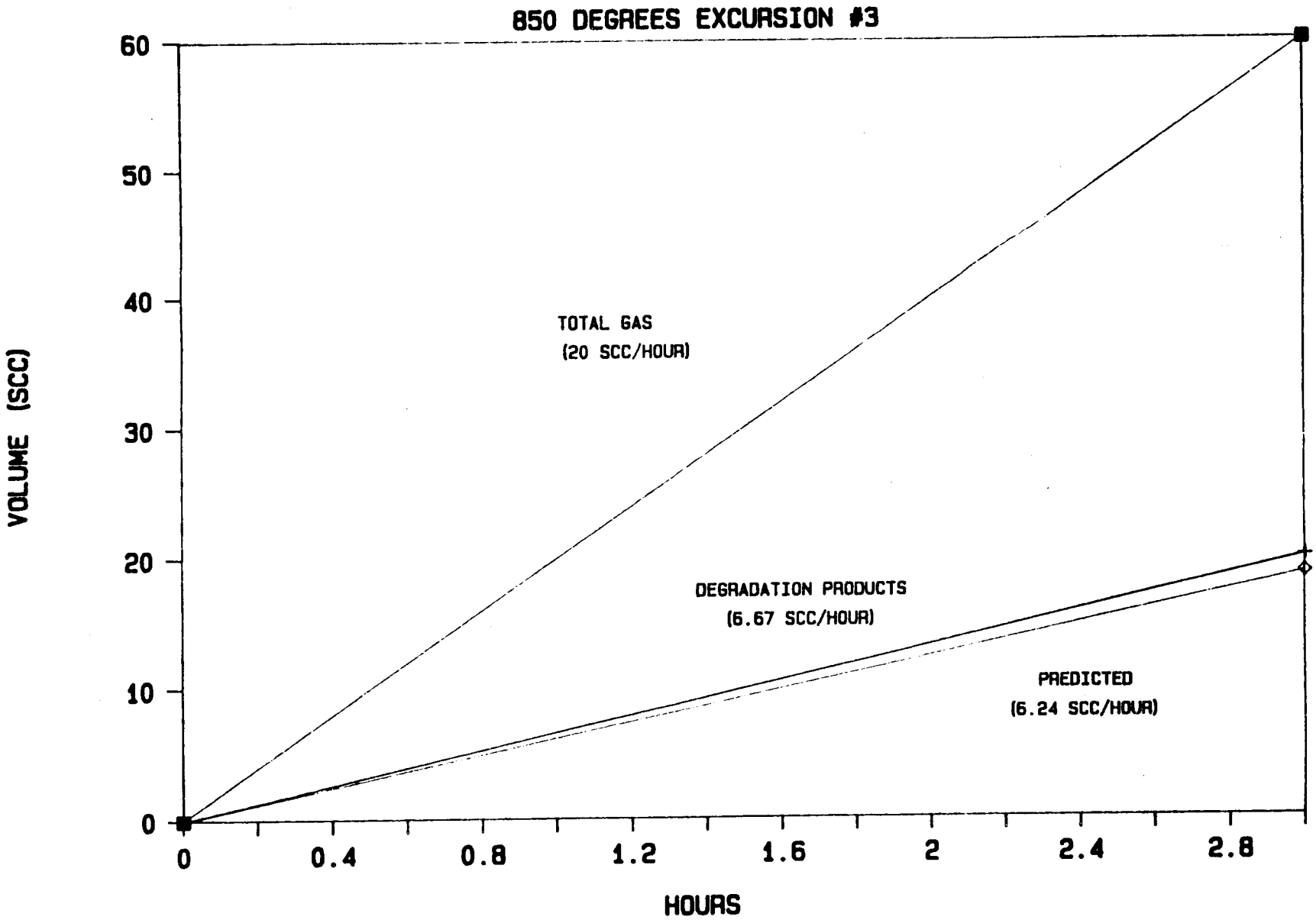


FIGURE 25 NONCONDENSIBLE GAS COLLECTED - 850°F

this initial conditioning period is complete, the pyrolytic degradation rate of pure toluene can be established. (440) hours and (187) hours were selected after examination of the data showed this to be when the assymptotic degradation rate was achieved. This is the classic trend seen in degradation experiments. References for several previous studies (see especially 14, 15, 18, 20 and 21) are provided in Section 8.0 of this report. An initial high rate followed by a much lower linear rate is typical in previous loop experiments with other organic fluids. Table 10 summarizes the statistical analysis of the gas data. Table 11 summarizes the liquid analysis.

The conclusion to be drawn from these tables is that a high correlation to a linear curve fit of the formation rate of the constituents has been established with respect to time. The last column in both tables is the correlation coefficient of the data set. This coefficient will fall between 0 and 1 and will indicate how closely the equation fits the experimental data: the closer to 1, the better the fit. The gas data shown in Table 10 are all an accurate fit, with correlation coefficients above 0.9. The liquid data has slightly more scatter, but the expected degradation products do show very high correlation (benzene and bibenzyl). The total of non-toluene products also shows a good correlation, with a correlation coefficient of 0.88.

A high correlation coefficient assures that the rate of toluene degradation at 750°F was established. Because of this and the reduced inventory remaining, concurrence from NASA-LeRC was received to pronounce the 750°F test complete at 3000 hours, and to proceed with the 850°F excursions.

5.5 Correlation with Capsule Based Predictions

Prior to performing the test portion of this program, Sundstrand predicted the toluene degradation rates for the dynamic loop based on the heater temperature profile and toluene capsule degradation results. This was done by dividing the heater tube into small incremental lengths. There is a corresponding fluid temperature and a corresponding

TABLE 10

REGRESSION ANALYSIS OF GAS CONSTITUENTS
440 THROUGH 2550 HOURS

	EQUATION (y = mx + b)		STANDARD DEVIATION	CORRELATION COEFFICIENT
	SLOPE (m) (scc/hr)	INTERCEPT (b) [scc initial]	[scc] S_x	
HYDROGEN	$1.7\ (10^{-2})$	94.5	$1.3\ (10^{1})$	0.911
METHANE	$2.1\ (10^{-2})$	-0.521	$6.8\ (10^{1})$	0.986
ETHANE	$2.7\ (10^{-4})$	-0.115	$2.0\ (10^{-1})$	0.984
PROPANE	$8.3\ (10^{-5})$	-0.045	$6.3\ (10^{-2})$	0.953
ARGON	$3.5\ (10^{-3})$	5.06	2.7	0.927
NITROGEN	$4.9\ (10^{-2})$	8.33	$3.6\ (10^{1})$	0.992
OXYGEN	$6.8\ (10^{-5})$	2.64	$7.3\ (10^{-2})$	0.681
CARBON MONOXIDE	$1.4\ (10^{-2})$	6.52	$1.1\ (10^{1})$	0.982
CARBON DIOXIDE	$2.0\ (10^{-3})$	-0.391	1.5	0.987
TOTAL GAS	$1.1\ (10^{-1})$	120	$7.5\ (10^{1})$	0.979
TOTAL DEGRADATION PRODUCTS	$3.8\ (10^{-2})$	93.9	$2.8\ (10^{1})$	0.977

y = SCC AT TIME x x - TIME [HRS] $S_x = \sqrt{\frac{\sum_i (X_i - \bar{X})^2}{n-1}}$

TABLE 11

REGRESSION ANALYSIS OF LIQUID CONSTITUENTS
187 THROUGH 2550 HOURS

	EQUATION (y = mx + b)		STANDARD DEVIATION (S_x)	CORRELATION COEFFICIENT
	SLOPE (m) [ppm/hr]	INTERCEPT (b) [ppm initial]	[ppm]	
PRE-BENZENE	$1.2\ (10^{-6})$	0.0042	$3.1\ (10^{-3})$	0.328
BENZENE	$7.8\ (10^{-6})$	0.0016	$6.8\ (10^{-3})$	0.958
BENZALDEHYDE	$2.3\ (10^{-6})$	-0.0007	$1.9\ (10^{-3})$	0.970
OTHER 1-RING	$-4.4\ (10^{-6})$	0.1312	$8.2\ (10^{-3})$	0.451
BIPHENYL	$1.8\ (10^{-6})$	0.0015	$2.9\ (10^{-3})$	0.505
BIBENZYL	$1.6\ (10^{-5})$	0.0065	$1.4\ (10^{-2})$	0.990
OTHER 2-RING	$3.6\ (10^{-6})$	0.0447	$1.1\ (10^{-2})$	0.276
3-RING AND HIGHER	$-2.6\ (10^{-7})$	0.0039	$3.5\ (10^{-3})$	0.063
TOTAL	$2.8\ (10^{-5})$	0.1932	$2.6\ (10^{-2})$	0.880

y = PPM AT TIME x x - TIME [HRS] $S_x = \sqrt{\frac{\sum_i (X_i - \bar{x})^2}{n-1}}$

mass of fluid associated with each heater tube increment. The analytical method accounts for both axial and radial temperature distributions within the tube. By reducing the heater to increments of fixed fluid mass at fixed temperatures, the experimental test results from isothermal capsules can be used to predict the degradation in each heater increment. The sum of each of the heater incremental degradation rates is the predicted rate for the entire heater.

5.5.1 Heater Profile

Knowledge of the temperature distribution along the toluene heater is necessary for predicting the amount of fluid degradation. For this experiment, thermocouples were mounted to the outside surface of the toluene heater tube and the entire assembly was submerged in the molten salt bath.

The measured temperature along the length of the toluene heater tube in the molten salt bath appears to be influenced by the 760°F salt bath. The thermocouples used to measure the outside tube wall temperature were soldered to the tubing. As Figure 26 shows, the measured temperature profile has 300°F liquid at the inlet to the heater, which is outside the salt bath. The next thermocouple is submerged in 760°F molten salt and reads over 700°F. The rapid rise between the two sensors indicates that the salt is strongly influencing the reading. A relatively simple heat transfer calculation was performed to predict the actual temperature distribution in the heater tubing and is also shown in Figure 26. The calculated temperature profiles were used as a basis for predicting liquid and gas degradation rates.

See Appendix A for the heat transfer calculations used to generate the tube wall and bulk fluid temperatures defined in Figure 26.

5.5.2 Liquid and Gas Degradation Predictions

Both gas and liquid degradation product formation rates for the dynamic loop were predicted utilizing the heater temperature profile and capsule

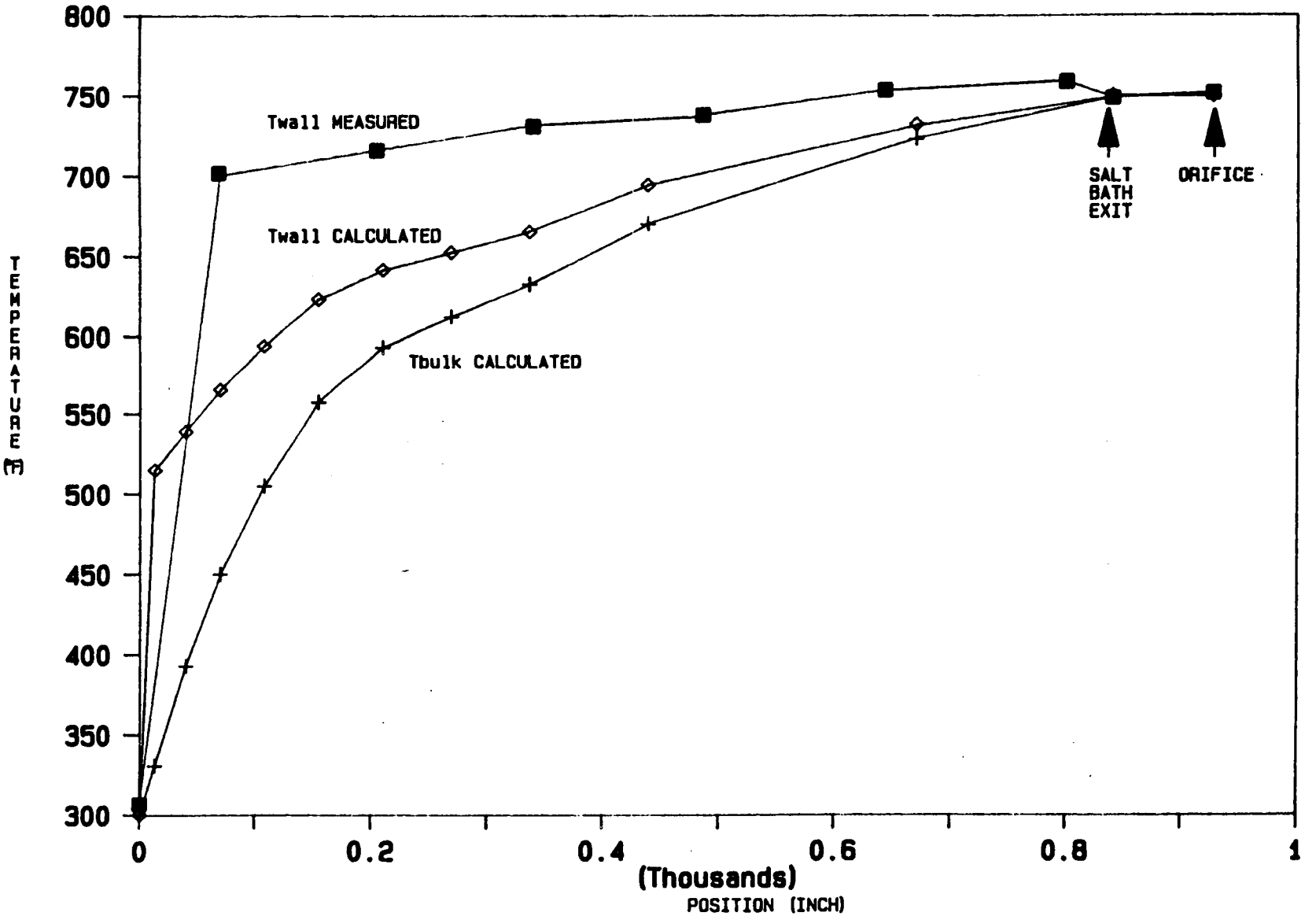


FIGURE 26 TOLUENE STABILITY LOOP HEATER TEMPERATURE PROFILE

test results. The calculations are shown in Appendix B. The predicted rates are summarized below:

Liquid	0.00265 $\frac{\text{grams non-toluene}}{\text{Hour}}$	
NC Gas	0.266	scc/Hour

Figure 27 is a comparison of measured and predicted noncondensible gas generation rates for a 750°F turbine inlet temperature. The gas generation rate is expressed in standard cubic centimeters (SCC). Both predicted and measured noncondensible gas generation rates are plotted as a function of loop operation time. The measured noncondensible gas generation rate was determined from a least squares curve fit of the measured data from 187 hours to 2996 hours, inclusive. The measured noncondensible gas evolution rate of 0.07 scc/hr is significantly less than the predicted evolution rate of .27 scc/hr.

There are several points to be considered in comparing the measured noncondensible gas evolution rate with the prediction. First, the measured rate is much less than the prediction. Therefore, designing the separation and removal system based on the predictions will assure adequate capability. The predictions are conservative. Second, the gas evolution is an insignificant contributor to total degradation. Total degradation (liquid plus noncondensibles) is almost totally liquid based and thus errors in the noncondensible prediction have almost no effect on total degradation. Third, there are several potential reasons for the discrepancy between predicted and measured noncondensible gas evolution; out leakage of noncondensible from the superatmospheric loop (particularly H_2 which can diffuse at significant rates through elastomeric seals), noncondensible becoming dissolved in the liquid and subsequently not measured (air is soluble to approximately 11% by volume at normal conditions), or potentially a difference in the degradation mechanisms in loops in which the noncondensibles are continuously removed and capsules in which the noncondensibles are maintained in contact with the hot fluid. It is also possible that the in-leakage

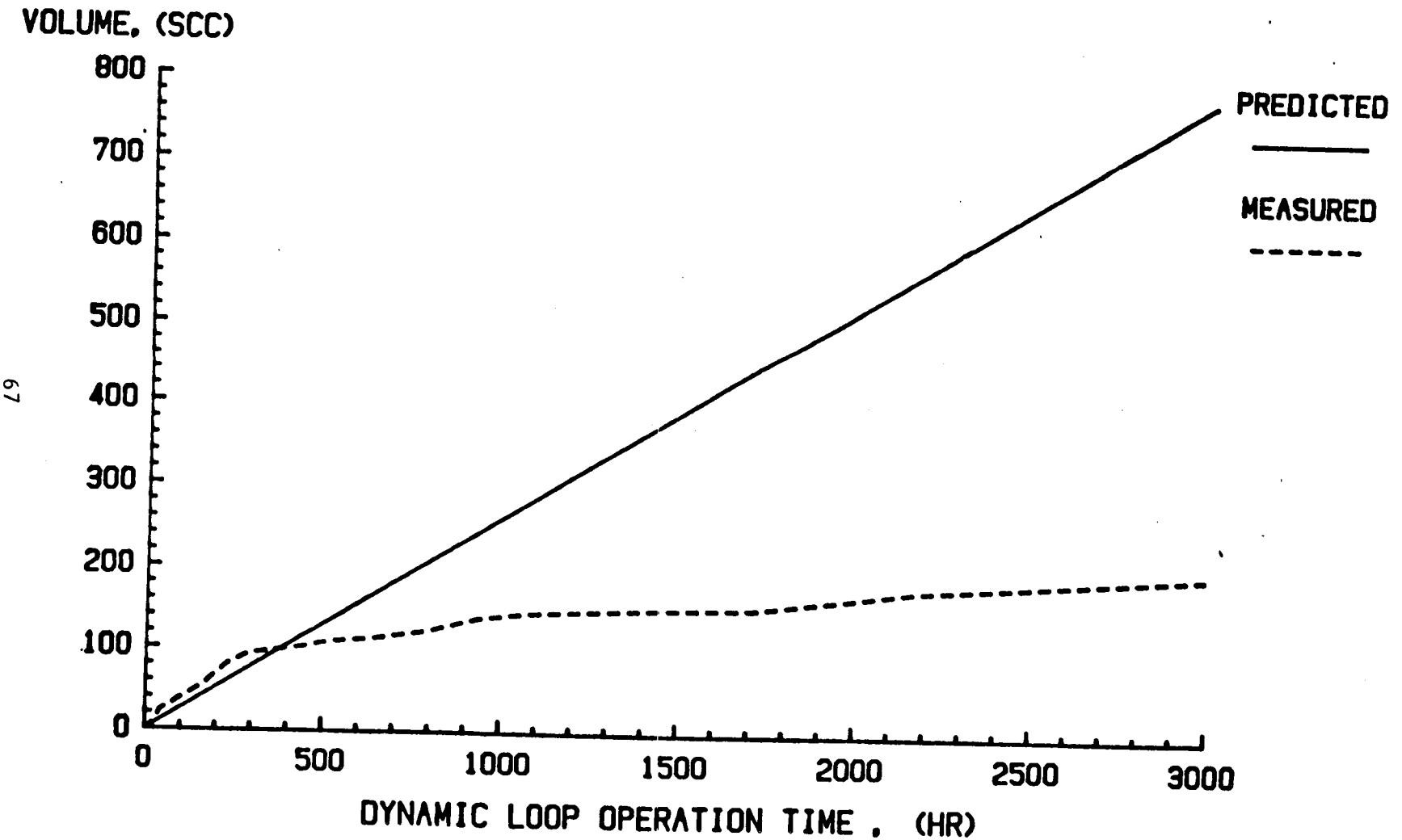


FIGURE 27 COMPARISON OF MEASURED AND PREDICTED NONCONDENSIBLE GAS (750°F)

previously described could have impacted the pyrolytic non-condensible accumulation rate. No attempt has been made to isolate the cause of the difference between measured and predicted rates.

Figure 28 is a comparison of the total measured liquid and predicted liquid degradation for a 750°F turbine inlet condition. Weight percent is a measure of the concentration level of soluble liquid degradation products. Weight percent is a ratio of the amount of liquid degradation to the total amount of toluene inventory contained in the stability loop. The measured rate of liquid degradation was determined from a least squares curve fit of the measured data from 187 hours to 2996 hours, inclusive. The measured evolution rate of 0.000034 weight percent per hour agrees well with the predicted evolution rate of .000027 weight percent per hour.

5.5.3 Effect of a Decreasing Inventory

The effect of a steadily decreasing fluid inventory resulting from periodic sampling must be taken into account when analyzing the toluene degradation rate from the stability loop. The fluid inventory is assumed to be a homogeneous mixture of the non-toluene products formed in the heater and the parent fluid inventory. The measured liquid degradation results are reported in weight percent. This is a weight ratio of non-toluene products to toluene. As the fluid inventory decreases, the amount of dilution of the non-toluene products decreases. In other words, the heater is forming a constant amount of non-toluene grams every hour. This constant rate of formation is being diluted in more fluid at the beginning of life than at the end of life. Reporting the as-measured weight percent values of each sample and not accounting for the decrease in the fluid inventory allowed for a timely presentation of the data. Only the grams/hour data reported at the end of this section have been corrected for this effect.

A fluid inventory history can be reconstructed by using the amount of fluid collected at the completion of the test and adding to it the amounts of fluid removed during the test. The amount of fluid inventory

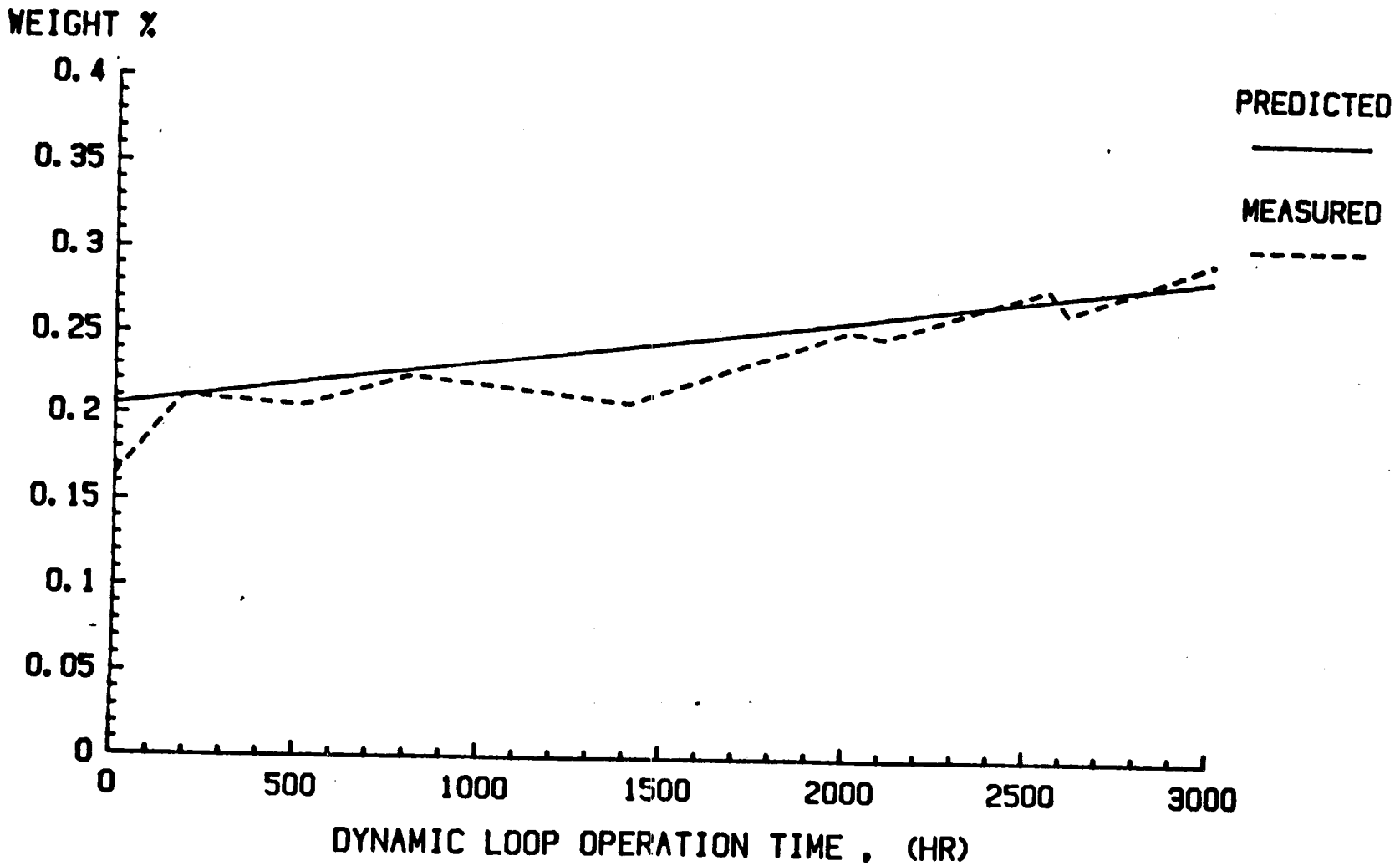


FIGURE 28 COMPARISON OF MEASURED AND PREDICTED LIQUID DEGRADATION (750°F)

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at the beginning of the test can then be determined. Table 12 summarizes the fluid inventory history. The draining procedure left a residual amount of fluid in the loop. An estimate of the amount was 1.0 pound. Every time a gas or liquid sample was taken, a small amount of fluid was lost overboard because of trapped volumes of liquid between valves in the sampling port. This line volume was determined and multiplied times the number of samples to arrive at a value of 0.4 pounds of inventory lost. The amount of fluid removed by each gas or liquid sample was measured and recorded. The gas sampling procedure removed 7.8 pounds and the liquid sampling removed 3.6 pounds over the duration of the testing.

Table 12 indicates that 21.7 lbs of toluene was in the test loop at the beginning of the test. This is less than the previously reported value of 36 lbs due to an easily identified occurrence. The initial fluid charge was 36 lbs, but prior to beginning the test the diaphragm of the pulse damper ruptured. An undetermined amount of fluid was lost overboard. This undetermined amount can now be identified as 14.3 pounds (36-21.7). It also shows that the fluid inventory at the end of the test was less than half of the initial charge of 21.7 pounds.

A detailed inventory history is attached in Appendix C.

The measured rate of degradation, taking the effect of a decreasing inventory into account, can now be calculated. The amount of grams of non-toluene in the loop at any time is calculated by multiplying the measured weight percent times the amount of fluid inventory in the system at the time the sample was taken. The total amount of grams formed over the significant interval of the test can be determined by the following equation for grams of non-toluene formed between 187 hours and 2996 hours:

TABLE 12

WORKING FLUID INVENTORY HISTORY

INVENTORY COLLECTED AT THE END OF TEST		8.9 LBS
	+	
ESTIMATED RESIDUAL INVENTORY IN LOOP AFTER DRAINING		1.0 LBS
	+	
INVENTORY LOST IN VALVE TEES DURING SAMPLING		0.4 LBS
	+	
INVENTORY REMOVED DURING GAS SAMPLES		7.8 LBS
	+	
INVENTORY REMOVED DURING LIQUID SAMPLES		3.6 LBS
INVENTORY AT THE START OF THE TEST		21.7 LBS

GRAMS FORMED DURING TEST INTERVAL	=	GRAMS AT 2996 HOURS	+	GRAMS FORMED DURING PERIOD BETWEEN 187 AND 2996	-	GRAMS AT 187 HOURS

= [19.45] + [4.38] - [17.00]

= 6.83 grams

MEASURED RATE OF FORMATION OF LIQUID NON-TOLUENE PRODUCTS = $\frac{6.83 \text{ GRAMS}}{(2996-187) \text{ HOURS}}$

$= 0.00243 \frac{\text{GRAMS}}{\text{HOUR}}$

A comparison of the measured and predicted rates of toluene degradation at 750°F is summarized below:

	Measured	Predicted
Liquid	0.00243 GRAMS/HOUR	0.00265 GRAMS/HOUR
Gas	0.07 SCC/HOUR	0.27 SCC/HOUR

The measured values for both gas and liquid are below the predicted values of degradation based on capsule test data. Capsule based predictions of the fluid degradation in an operating system appears to be a conservative approach.

5.6 Post-Test Inspection of Hardware

On December 2nd, the power to the salt bath heaters was shut off and the stability loop was prepared for disassembly. The fluid inventory was drained into a precision cleaned container for storage until the

measurement of post-test thermophysical properties could be performed. Once the system was drained, the line between the salt bath heater and the turbine simulation orifice was removed. The regenerator housing and the filter element at the feed pump outlet were also removed. The visual appearance of the interior surfaces was very clean, with no indications of insoluble products. Chemical analysis samples and photographs were taken of all the areas of significance. Figures 29, 30, 31, 32, 33, 34 and 35 document the condition of the hardware. The visual and chemical analysis results from the post-test examination are summarized in Table 13. The reference sample numbers on the photographs in Figures 29 through 35 are from Table 13.

The significance of Table 13 is that as expected there were no signs of insoluble toluene degradation products detected in the filter element assembly, the interior surfaces of the heater supply line or the interior surfaces of the Regenerator Housing. There was no evidence of coating or plating of heat exchanger surfaces by toluene degradation products. The most noticeable feature was at the outlet of the turbine simulation orifice (Sample #4, 5, 6, 7). Based on the visual appearance and chemical analysis results, this deposit was contamination not originating from fluid degradation. The deposit was due to external contamination collecting in this area. The source for most of the particles observed on the steel plate below the orifice was from wear (reference sample 5). Shiny areas of wear were visible between the turbine simulation coils and the steel plate used to contain the fluid in the heat exchange surfaces. Vibration levels were increased during the last 400 hours of testing due to a failure of the pulse damper diaphragm. The failed damper was valved out of the active flow circuit to complete the final 400 hours of testing. The lack of a pulse damper at the outlet of the feed pump resulted in regular pressure pulsations through the equipment and caused an increase in wear between the tubing and plate. An additional feature in Figure 33 and 34 are the brown discoloration areas located 180° apart. These areas are from a welding operation performed prior to starting the experiment. Two lifting rings were added to the assembly and can be seen in Figure 14.

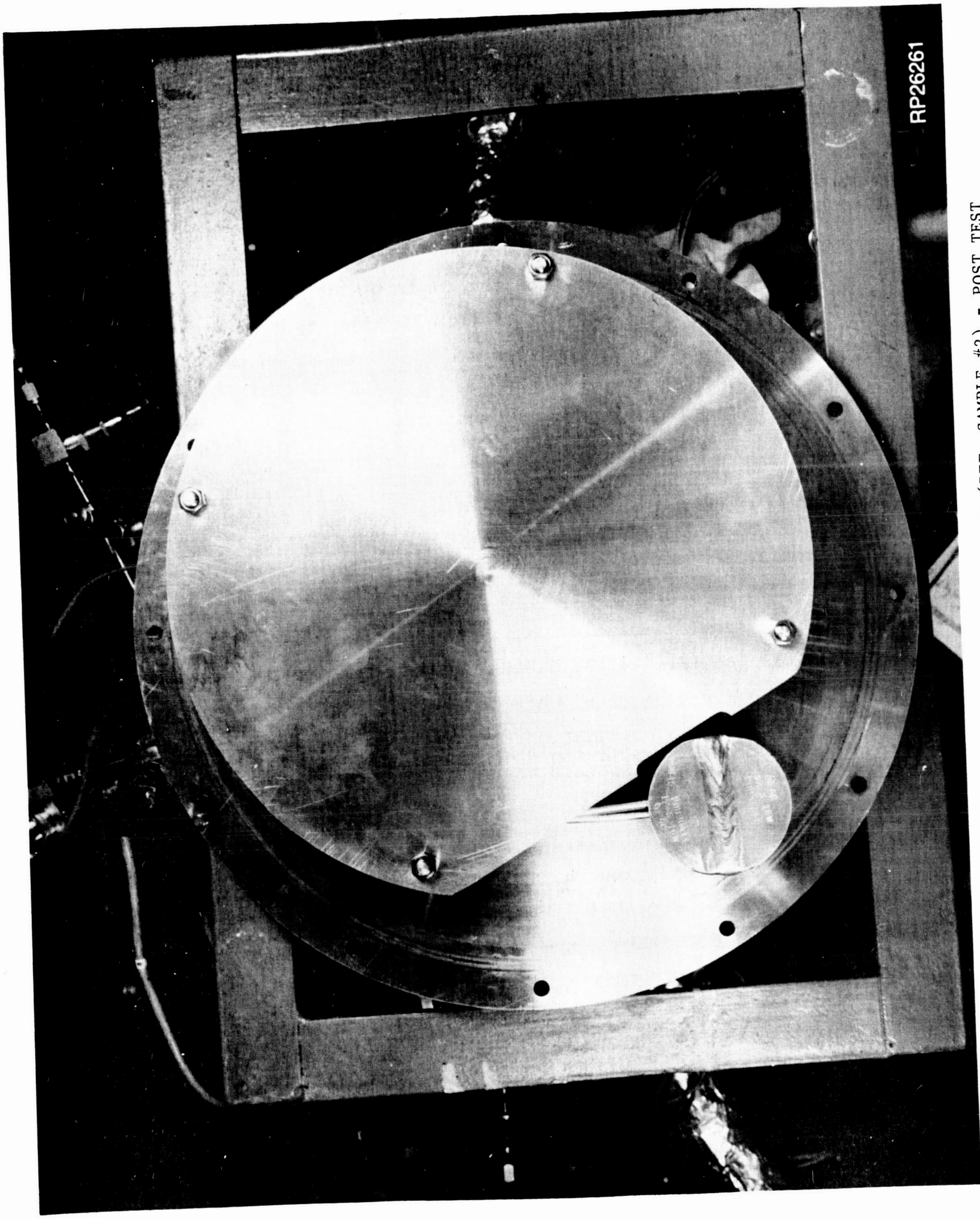

FIGURE 29 TOP VIEW OF REGENERATOR ASSEMBLY (REF. SAMPLE #2) - POST TEST

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FIGURE 30 VAPOR SUPPLY LINE AT ORIFICE (REF. SAMPLE #3) - POST TEST

FIGURE 31 UPSTREAM SIDE OF ORIFICE (REF. SAMPLE #3) - POST TEST

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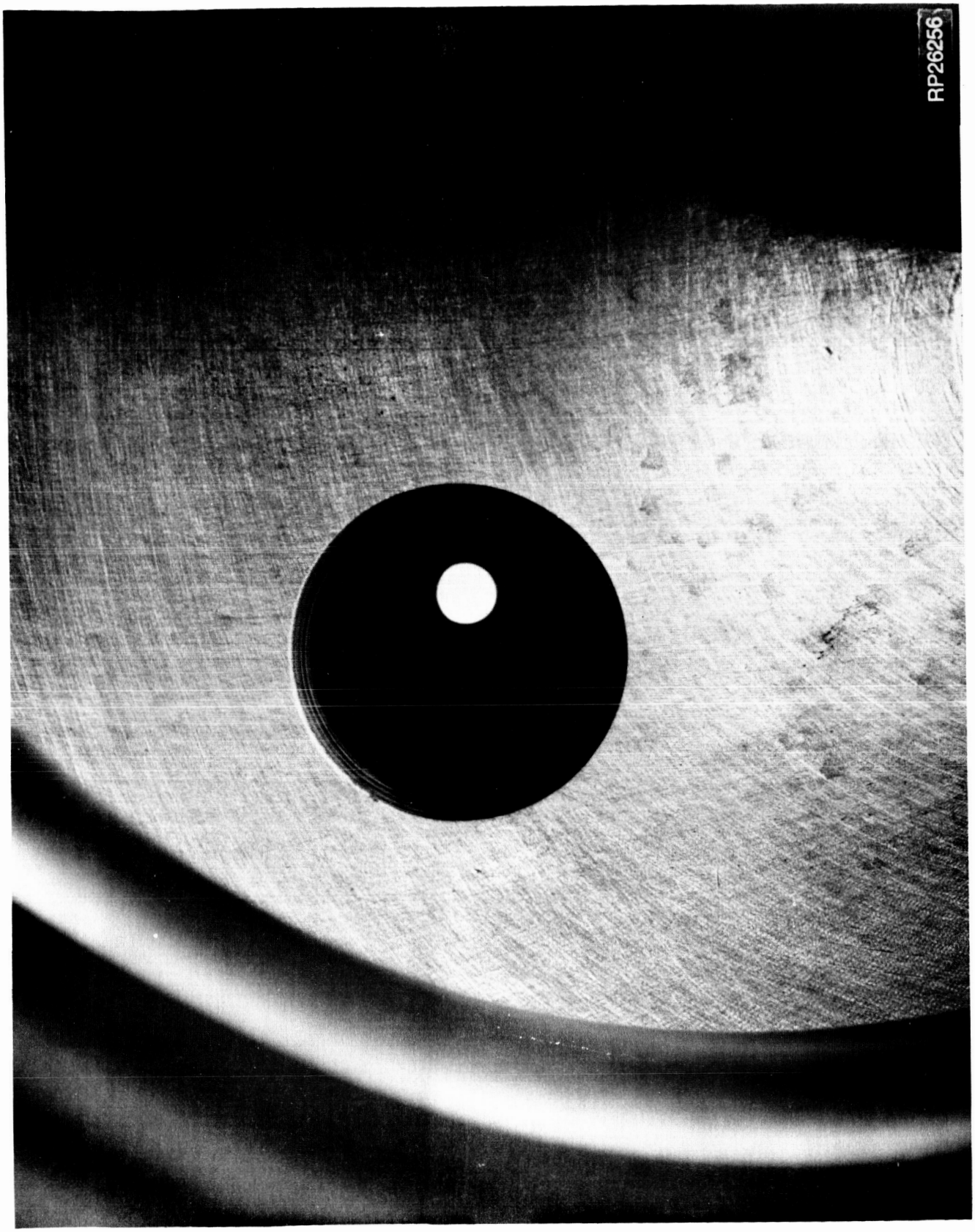

FIGURE 32 OUTLET OF ORIFICE (REF. SAMPLE #7) - POST TEST

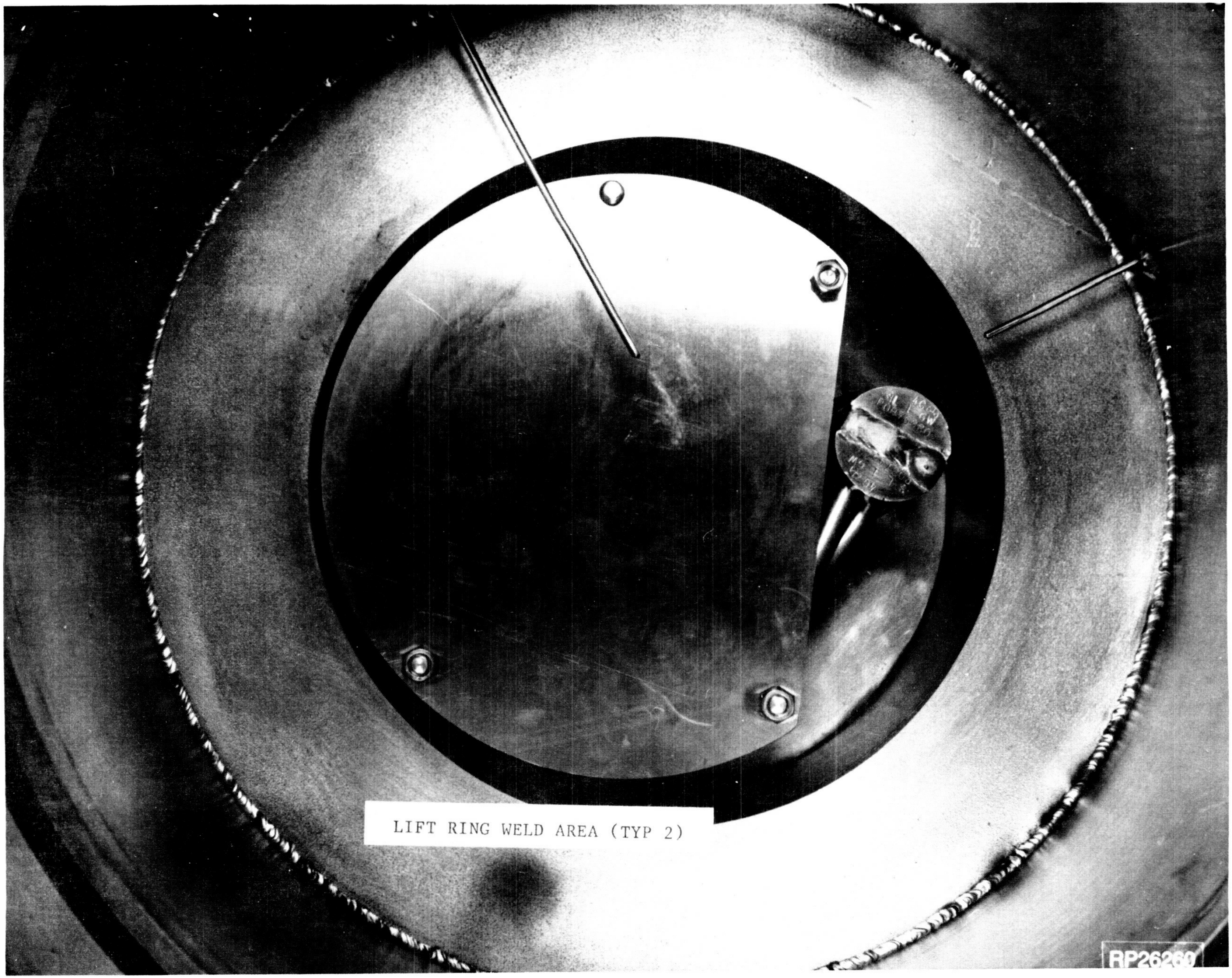

FIGURE 33 TURBINE SIMULATOR HEAT EXCHANGER - POST TEST

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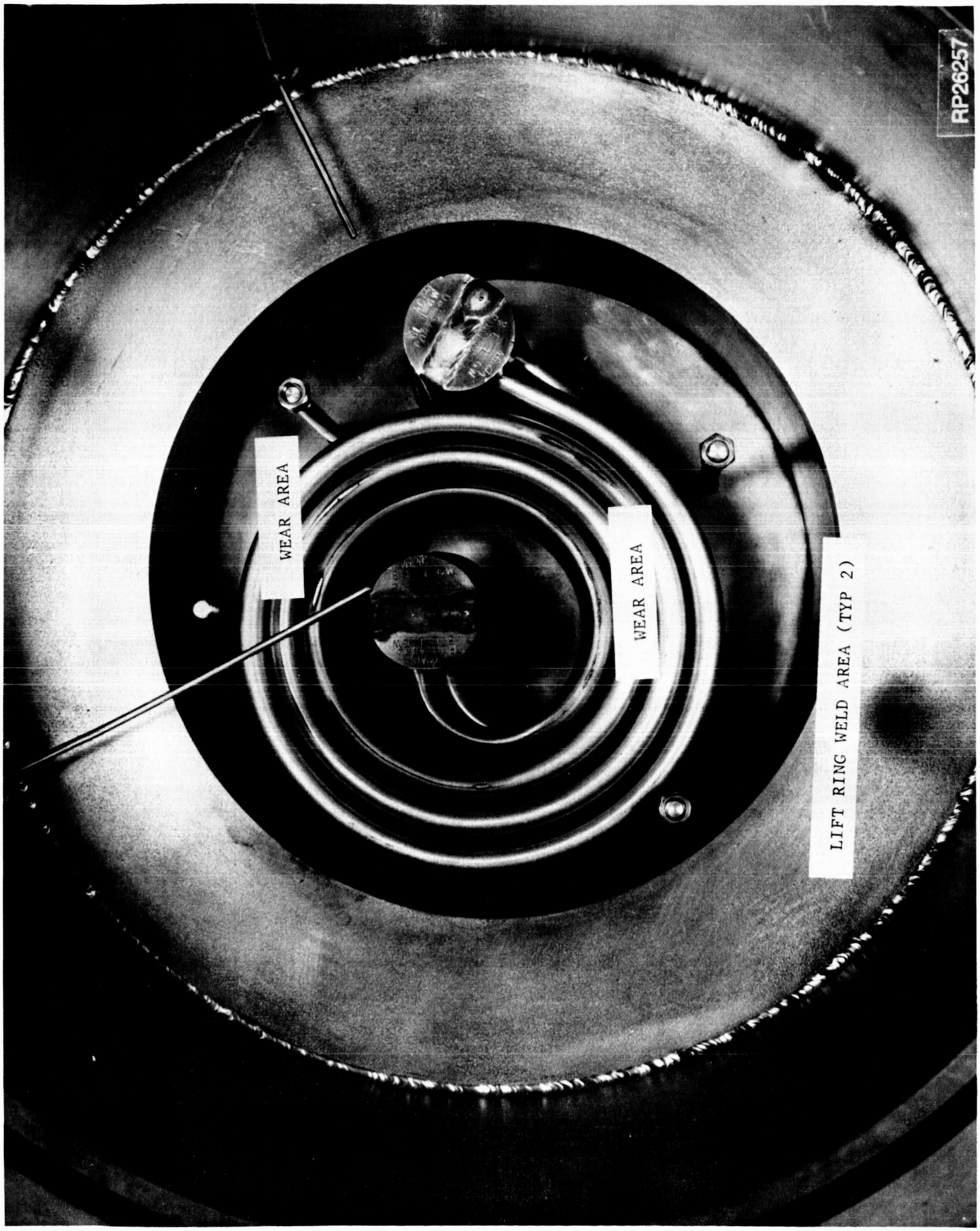


FIGURE 34 TURBINE SIMULATOR HEAT EXCHANGER - PLATE REMOVED (REF. SAMPLE #4) - POST TEST

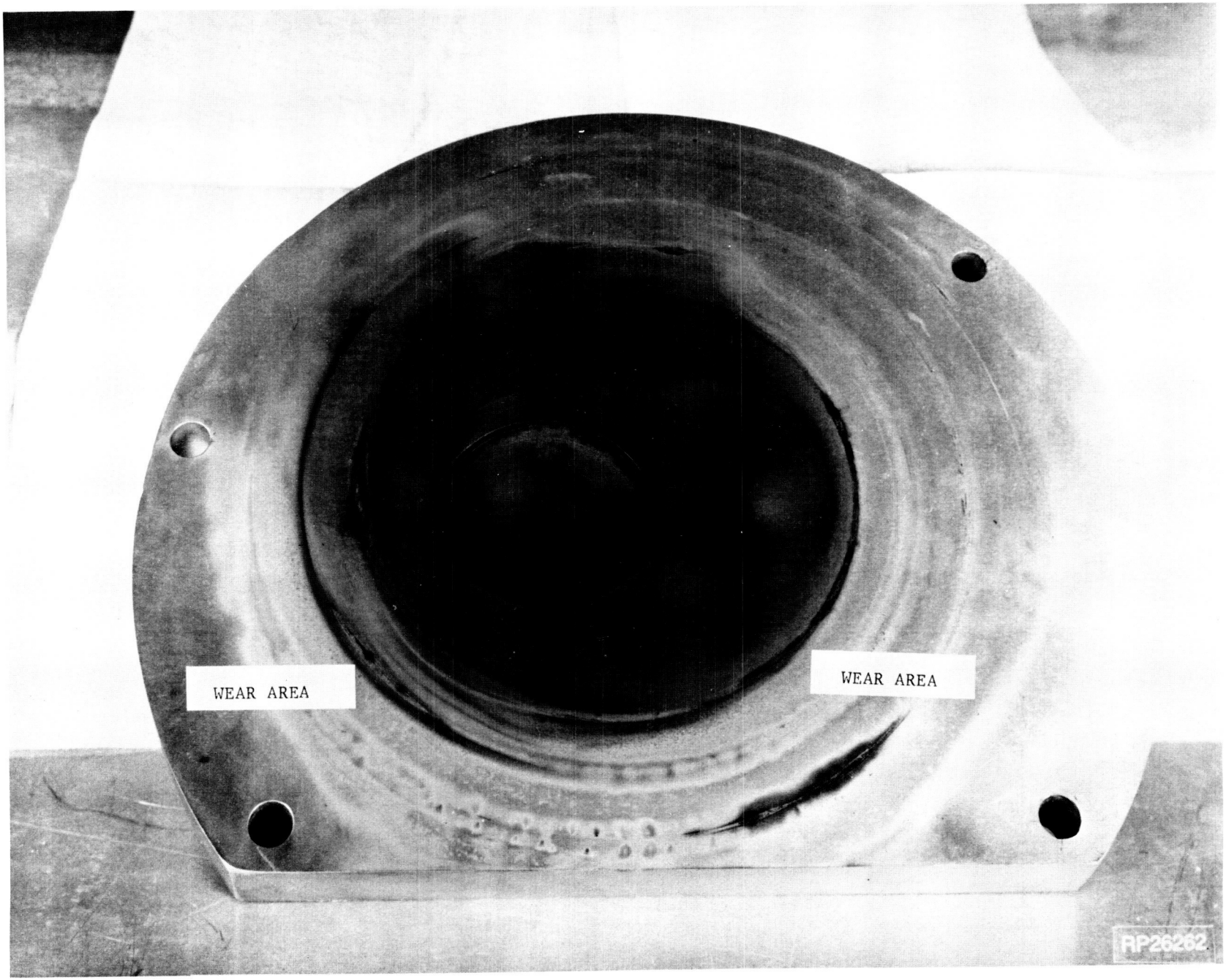


FIGURE 35 TURBINE SIMULATOR PLATE (REF. SAMPLE #5 AND #6) - POST TEST

TABLE 13

POST-TEST SAMPLE RESULTS

SAMPLE #	SAMPLE LOCATION	VISUAL DESCRIPTION	CHEMICAL ANALYSIS	PROBABLE SOURCE
1	BACKFLUSH OF FILTER ELEMENT	-QUITE A FEW METALLIC PARTICLES	X-RAY -Fe, Cr, Ni	-STAINLESS STEEL
		-FINE, GRAY-BLACK BACKGROUND ON FILTER PATCH -SOME PLASTIC FILM VISIBLE. -OTHER NON-METALLICS (BROWN, OFF-WHITE, BLACK)	-SMALLER AMOUNTS OF Si, Ca, Al, P, S, K, Ti	-CONTAMINATION
			INFRARED -SMALL BANDS AT 1215 AND 1160 CM^{-1}	-TEFLON
			-OTHER SMALL BANDS. ONE INDICATING A C-O BOND	-OXIDATION OR ESTER BASED OIL CONTAMINATION
2	BASE PLATE OF REGENERATOR AROUND PERIMETER OF REGENERATOR COILS	-CLEAR, COLORLESS LIQUID	SOLUBLE IN TOLUENE	-SOLUBLE TOLUENE DEGRADATION PRODUCTS
			GAS CHROMATOGRAPHY -PRIMARILY 2-RING PRODUCTS. SMALL AMOUNT OF 1-RING (< 2%) PRODUCTS SIMILAR TO SAMPLES FROM LOOP	
			INFRARED -TYPICAL OF AROMATIC HYDROCARBON	

TABLE 13 (continued)

SAMPLE #	SAMPLE LOCATION	VISUAL DESCRIPTION	CHEMICAL ANALYSIS	PROBABLE SOURCE
3	-ID OF VAPORIZER-TO-ORIFICE LINE AT ORIFICE END -IMMEDIATELY UPSTREAM OF ORIFICE	FINE BROWN PARTICLES REMOVED BY COTTON SWAB	X-RAY -Fe, Cr, Ni -SMALLER AMOUNTS OF Si AND Al INFRARED -INSUFFICIENT SAMPLE	-STAINLESS STEEL -CONTAMINATION
4	EXTERIOR SURFACES OF TURBINE SIMULATION COIL	FINE BROWN PARTICLES REMOVED BY COTTON SWAB	X-RAY -Fe, Cr, Ni Cr WAS HIGHER THAN EXPECTED -LESSER AMOUNTS OF Si, Al, S, Cu, Ca INFRARED -INSUFFICIENT SAMPLE	-STAINLESS STEEL -CONTAMINATION
5	STEEL PLATE DIRECTLY BELOW OUTLET OF ORIFICE	BLACK PARTICLES SURROUNDING SHINY AREAS OF WEAR BETWEEN THE COILS AND PLATE	X-RAY -Fe, Cr, Ni -LESSER AMOUNTS OF Si, S, Mn, Ca, p INFRARED -SOME ORGANIC PROBABLE	-STAINLESS STEEL -NO IDENTIFICATION POSSIBLE

TABLE 13 (continued)

SAMPLE #	SAMPLE LOCATION	VISUAL DESCRIPTION	CHEMICAL ANALYSIS	PROBABLE SOURCE
6	STEEL PLATE DIRECTLY BELOW OUTLET OF ORIFICE	FINE BROWN PARTICLES REMOVED BY COTTON SWAB	X-RAY -Fe, Cr, Ni Si IS MINOR ELEMENT -LESSER AMOUNTS OF Cu, Al, S, Ca, Mn, P INFRARED -INSUFFICIENT SAMPLE	-STAINLESS STEEL -CONTAMINATION
7	OUTLET OF ORIFICE	FINE BROWN PARTICLES REMOVED BY COTTON SWAB	X-RAY -Fe, Cr, Ni -LESSER AMOUNTS OF Si, Al, Mn, S, Ca, K, Cu	-STAINLESS STEEL -CONTAMINATION

Following the sample analysis, the stability loop was reassembled and pressurized with argon for indefinite, safe storage.

5.7 Post-Test Measurement of Toluene Properties

One of the primary concerns regarding degradation of the working fluid is that an accumulation of soluble non-toluene constituents may reach a level that alters the bulk fluid properties of the parent fluid. A change in fluid properties may result in a deterioration of power cycle performance. To quantify the change in fluid properties due to the addition of non-toluene compounds, the fluid drained from the stability loop and a sample of fresh toluene were sent to a laboratory to measure various bulk fluid properties. The laboratory and analytical work was performed by Wiltec Research Company, Inc. The test program performed for both the partially degraded and fresh toluene included:

- -entropy as a function of temperature
- -enthalpy as a function of temperature
- -specific volume as a function of temperature

The range of interest was from 15 psia to 600 psia and from 150^{o}F to 750^{o}F. The specific test points were chosen to correspond to the ORC state points.

Direct comparisons of fluid and thermodynamic properties were performed by Wiltec. Two toluene samples were delivered to Wiltec. The first sample was fresh reagent grade toluene (99.835% toluene). The second sample was from the stability loop after 3410 hours of operation at 750^{o}F and 850^{o}F (99.673%). At this level of degradation, the fluid still meets the requirements of reagent grade toluene. The Wiltec report is attached as Appendix D. The results of the analysis found that a concentration of 0.33% degradation impurities have a negligible effect on the thermodynamic properties of toluene.

Wiltec performed a literature search for property values finding a number of sources. The most complete set was used as a basis for developing a correlation model using the Hemholtz free energy function

as a basis. The RMS error for the correlation model compared to measured results for liquid density as an example was 0.4% which shows good agreement. The average difference between the corresponding fresh and degraded toluene densities was to 0.03%. The only area in which there is a perceptible difference between fresh and degraded fluid properties is in the dew point region. The derived thermodynamic properties are quite sensitive to trace heavy impurities in this region. At 5 psia, the difference between dew point and bubble point is about 20°F. This will not be a problem because at higher pressures this difference disappears and as the fluid expands nearly isentropically through the turbine the superheat increases. The maximum difference in the T-h plots at 5 psia is about 5°F in the dew point region. For comparison purposes, Tables 14 A and B contain density and isothermal enthalpy data over the full test range for the reagent grade and degraded fluid. Complete data is available in Tables 4 through 12 of Appendix D.

In addition to the thermodynamic property measurements performed by Wiltec, Sundstrand measured several bulk fluid properties of new and partially degraded toluene. The properties measured were kinematic viscosity at 100°F, specific gravity at 60°F, and refractive index at 140°F. These temperatures were selected because they are Sundstrand laboratory standards for these tests. Table 15 summarizes the results and show a negligible difference between new and partially degraded toluene bulk properties.

TABLE 14

DENSITY AND ENTHALPY COMPARISON

A. DENSITY COMPARISON

T (°K)	P (Bar)	ρ (g/cc)	
		Reagent	Degraded
300	1	.8601	.8581
422	42	.7480	.7482
590	103	.5505	.5515
588	13	.0289	.0289
644	54	.1645	.1693
672	99	.3547	.3624

B. ISOTHERMAL ENTHALPY COMPARISON

T (°K)	P (Bar)		Delta H (KJ/ mole)	
	in	out	Reagent	Degraded
339	7	1	-.036	-.037
	41	1	-.267	-.271
	48.3	1	-.300	-.307
672	7	1	.52	.56
	41	1	5.12	5.10
	48.3	1	6.21	6.30

TABLE 15

BULK FLUID PROPERTY COMPARISON

	NEW FLUID (99.835% TOLUENE)	PARTIALLY DEGRADED FLUID (99.673% TOLUENE)
KINEMATIC VISCOSITY AT 100°F (CENTISTOKE)	0.560	0.565
SPECIFIC GRAVITY AT 60°F	0.867	0.868
REFRACTIVE INDEX AT 140°F	1.4744	1.4745

6.0 Conclusions

Conclusions about toluene liquid degradation can be summarized as follows: (1) The measured liquid degradation rate was very low, indicating that toluene pyrolytic degradation in an ORC is not a significant issue at 750°F, (2) The quantity and identity of all degradation products were generally as expected from capsule tests, (3) All products are soluble in toluene and non-corrosive, (4) Liquid degradation results obtained from capsule tests were used to accurately predict liquid degradation in a dynamic loop.

Conclusions about toluene noncondensible gas degradation can be summarized as follows: (1) The measured noncondensible gas generation rate was low; (2) The gaseous products of degradation were as expected from capsule tests, and (3) The method for relating capsule degradation to dynamic loop over-predicts the generation rate of noncondensible gas in a dynamic loop. It should be mentioned that the noncondensible gas generation rate is primarily used to size the noncondensible gas removal system for an ORC and that noncondensible gases don't significantly affect the toluene bulk fluid properties. This is because, on a mass basis, noncondensible degradation products constitute a very small portion of the total degradation (less than 1 percent). The presence of non-condensibles can affect the heat transfer characteristics in a shear flow condenser and subsequently the performance of an ORC power system. The magnitude of this effect was not addressed by these tests and remains the subject of further work.

Toluene degradation is primarily composed of liquid degradation products. A sufficient accumulation of liquid degradation products has the potential for altering the bulk fluid properties of toluene, and subsequently the heat transfer characteristics. The liquid degradation rate is important in determining the useful life of the toluene, especially when it is used as a working fluid in a power system. Post-test bulk fluid property measurements of 0.34% degraded toluene found no difference between degraded and fresh fluid.

Short periods of operation at 850°F indicate that the working fluid inventory is tolerant to periods of over-temperature exposure. The impact of the over-temperature exposure on the amount of liquid degradation products formed was undetectable. The rate of noncondensible gas formation was, as expected, higher that at 750°F (higher by a factor of 23). The higher measured rate agreed with capsule based predictions for operation at 850°F (refer to Section 5.3.2 of this report). An increase in the accumulation of gas could be readily handled by the gas removal system of the ORC.

Results obtained from the toluene stability loop test program verify an analytical method which can be used to predict toluene pyrolytic degradation for an organic Rankine cycle power system. The close agreement between measured and predicted liquid degradation suggests that toluene degradation in a power system loop can be predicted using toluene capsule degradation results. Applying this technique to the proposed Space Station design predicts 1% degradation in 30 years. The thermophysical properties measurements on fluid with 0.34% showed no change and indicates qualitatively that 30-year fluid life is achievable.

7.0 Recommendations

Toluene pyrolytic degradation does not appear to be a significant issue at 750°F. It is, therefore, recommended that the toluene stability loop be utilized to investigate toluene stability at turbine simulator inlet temperatures above 750°F (e.g. 800°F or 850°F) for extended periods of time. An increase in the maximum cycle temperature would result in a significant improvement in overall cycle performance.

As part of any further testing, several improvements could be incorporated. The condenser could be modified to contain a much larger fluid inventory and a gas sampling procedure could be developed to prevent removing large quantities of liquid inventory. Both of these steps would minimize the effects of a decreasing fluid inventory over the life of the experiment.

The test facility constructed for the subject contract has been modified to run performance tests on a prototypic toluene heater design for the Space Station ORC application.[6] The heater fabricated and operated in the test rig will be a single heater tube, identical to the 40 parallel heater tubes in the flight design Solar Receiver. Fluid endurance testing on a prototypic heater design would further verify the predicted degradation for the Space Station ORC application.

The classic trend seen in fluid degradation experiments is an initially high rate of degradation, followed by a much lower rate. This trend was seen in this experiment. A series of tests could be performed using the existing facility to identify the source of the high rate of degradation. Possible sources include initial contaminants in the fresh fluid, contaminants in the internal plumbing, or "conditioning" of the internal surfaces. A test series of this nature would be useful to understand and accommodate for this trend in a flight design acceptance/burn-in test.

The concentration level of liquid degradation necessary to affect toluene heat transfer characteristics should be quantitatively

determined. Sundstrand currently believes that when the liquid degradation products reach a concentration of approximately 10 percent, the toluene bulk fluid properties are affected to the point where cycle efficiency is degraded. The subject contract measured the thermodynamic properties of partially degraded toluene at the dynamic loop produced concentration level of 0.34%. Further property measurements of higher contaminant concentrations (i.e., 1%, 5%, 10%, 15%, etc.) are also recommended. Higher concentrations of contaminants could be achieved by several methods, such as mixing the major constituents together in the ratios detected in this program, or heating the toluene in a static capsule, or operating the stability loop at 750^{o}F for an extended time period, or operating the stability loop at higher temperatures for a shorter time. The impact of fluid property changes on the power cycle performance could then be evaluated.

8.0 References

1. Hall, C.N., and Mullin, J.P., "Dynamic Power - A Key to the Promise of Space," Twenty-Second Space Congress, April, 1985.
2. Brouns, et al., "Kilowatt Isotope Power System," IECEC 779283.
3. Sorensen, et al., "Status Report of the Dynamic Isotope Power System," IECEC 799299.
4. Prickett, et al., "Applications of the Dynamic Isotope Power System to a Multimission Spacecraft," IECEC 799301.
5. Raab, "Unique Features of Dynamic Isotope Power Systems for High Requirements Spacecraft," Proceedings of the 15th IECEC.
6. Grosskopf, W.J., and Binz, E.F., "Solar Dynamic Power for Space Station," Twenty-Third Space Congress, April 1986.
7. AER 2566
   "ORC Working Fluid Stability Test Plan"
8. AER 2733
   "Test Plan for NASA-LeRC Space Station Advanced Development Contract: Toluene RFMD and Condenser Test Stand
9. AER 2800
   "Final Report-Toluene Rotary Fluid Management Device and Shear Flow Condenser"
10. AER 2671
    "Measurement of Toluene Degradation Performed By Argonne National Labs-Final Report"
11. Drawing ED 16310
    KIPS Combined Test Rig
12. Drawing EP 2809-1803
    Turbine/Regenerator Assembly
13. Drawing EP 2809-1802
    Condenser Assembly
14. Greenlee, W.J., "Organic Rankine Bottoming Cycle Working Fluid Study" AER 1974, 30 September 1981

15. Curran, H.M., "The Use of Organic Working Fluids in Rankine Engines," IECEC 809194

16. Miller, D.R., "Toluene Thermal Stability" PIR No. 188

17. Jain, M.L., "Test Plan: Determination of Working Fluid Degradation in Organic Rankine Cycle Power Systems" Argonne National Laboratory, February 25, 1983

18. Niggemann, R.E., et al, "Organic Working Fluid Thermal Stability Investigation" AEC Research and Development Report No. SAN-651-101

19. Cole, R.L., et al, "Measurement of Toluene Degradation: Final Report" Argonne National Laboratories, August 1986

20. "A Guide to Understanding and Interpreting Thermal Stability Data for Heat Transfer Fluids", Dow Chemical Company Form No. 176-1373-83

21. Jain, M.L., et al, "Organic Rankine Cycle Power Systems Working Fluids Study: Topical Report No. 1 - Fluorinol 85" ANL/CNSV-TM-182

Appendix A - 750 °F Vaporizer Profile Calculation

750 DEG-F VAPORIZER PROFILE

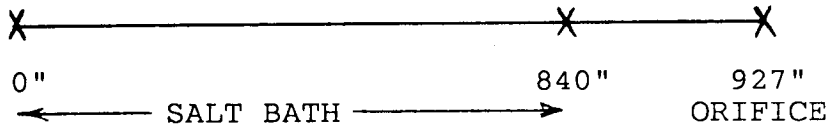
REVISION TO 10/22/86 MEMO, SPA-86-0940-M

REASON: CALCULATION OF TEMPERATURE PROFILE WAS PERFORMED ASSUMING 927 INCHES OF TUBING WAS IN SALT BATH. ACTUALLY ONLY HAD 840 INCHES IN SALT BATH.

KNOWN

MDOT = 270 LBM/HR	TSALT = 765 DEG-F
TIN = 300 DEG-F	TOUT = 750 DEG-F
PIN = 600 PSIA	POUT = 600 PSIA

(1/2) INCH OD X 0.035 WALL



ASSUME NO Q LOST IN 840-927 SECTION.

C-2

CALCULATE END-TO-END Q

Q = (MDOT)*(ENTHALPY CHANGE)
= (270 LBM/HR)*(271-(-64)BTU/LBM)
= 92125 BTU/HR

Q PER SEGMENT

DIVIDE VAPORIZER INTO (10) SEGMENTS OF UNEQUAL LENGTH. EACH SEGMENT HAS CONSTANT QIN. LENGTHS OF SEGMENT WILL BE CALCULATED LATER.

(CHANGE IN SEGMENT Q) = (Q/10)
= 9212.5 BTU/HR

ENTHALPY CHANGE AND BULK TEMPERATURE FOR SEGMENT

CALCULATE THE CHANGE IN ENTHALPY FOR EACH SEGMENT AND LOOK UP CORRESPONDING TEMPERATURE AT 600 PSIA.

(ENTHALPY CHANGE) = $\Delta H = (\Delta Q/MDOT) = 33.5$ BTU/LBM

TBULK	ENTHALPY, H	"END POINT" TBULK @ 600 PSIA	"AVERAGE OF SEGMENT" TBULK
300 F	-64	300 F	
			331 F
300	-30.5	363	
			393
300	3.0	423	
			450
300	36.5	477	
			505
300	70.0	533	
			557
300	103.5	580	
			593
300	137.0	605	
			612
300	170.5	618	
			632
300	204.0	645	
			670
300	237.5	695	
			723
750	271.0	750	

INTERIOR HEAT TRANSFER COEFFICIENT

hi = (0.023)*(k/di)*(Re^0.8)*(Pr^0.33)

(Turbelent flow in circular tubes--Colburn)

TBULK AVG (DEG-F)	hi (BTU/ LB-FT2-R)	μ (LB/ FT-HR)	Re (G*di / μ)	Cp (BTU/ LB-R)	kb (BTU/ HR-FT-R)	Pr (μ*Cp/ kb)
331	202.1	0.38	25833	0.53	0.064	3.147
393	223.8	0.29	33851	0.56	0.060	2.707
450	242.5	0.23	42682	0.59	0.056	2.423
505	258.1	0.18	54538	0.63	0.049	2.314
557	284.6	0.15	65445	0.71	0.048	2.228
593	325.2	0.13	75514	1.20	0.041	3.805
612	348.4	0.11	89243	1.36	0.038	3.937
632	365.4	0.090	109075	1.48	0.034	3.918
670	322.0	0.062	158335	0.88	0.028	1.949
723	315.6	0.048	204517	0.67	0.026	1.235

G = (MDOT/AREA) = (275 LB/HR)/(Ai) = 272689 LB/HR-FT2

where di = 0.036 FT and Ai = (3.14159/4)*(di*di)

CALCULATE TWALL

(hsalt)*(Aod)*(Tsalt-Twall) = (hi)*(Aid)*(Twall-Tbulk)

h = (0.53)*(k/do)*[(Gr/ΔT)*(Pr*ΔT)]^0.25

(NATURAL CONVECTION FOR HORIZONTAL CYLINDERS--MCADAMS)

FOR THE SALT PROPERTIES THIS REDUCES TO

hsalt = (32.2)*(ΔT^0.25)

THEREFORE

$$\frac{(Twall - Tbulk)}{(Tsalt - Twall)^{0.25}} = \frac{43.54}{hi}$$

Tsalt = 765 DEG-F

Tbulk (DEG-F)	hi (BTU/HR-FT2-F)	(43.54)/hi	Twall (DEG-F)
331	202.1	0.215	529
393	223.8	0.194	551
450	242.5	0.180	576
505	258.1	0.169	603
557	284.6	0.153	628
593	325.2	0.134	646
612	348.4	0.125	656
632	365.4	0.119	668
670	322.0	0.135	697
723	315.6	0.138	733

di = 0.43 in do = 0.50 in

CALCULATE INSIDE HEAT TRANSFER COEFFICIENT AND AREA

(1/Ui) = (1/hi) + (ri/kw)*ln*(ro/ri)

(Overall heat transfer coefficient--Rhosenow and Choi)

di = 0.43 in twall = 0.035 in
do = 0.50 in kwall = 10 Btu/hr-ft-R

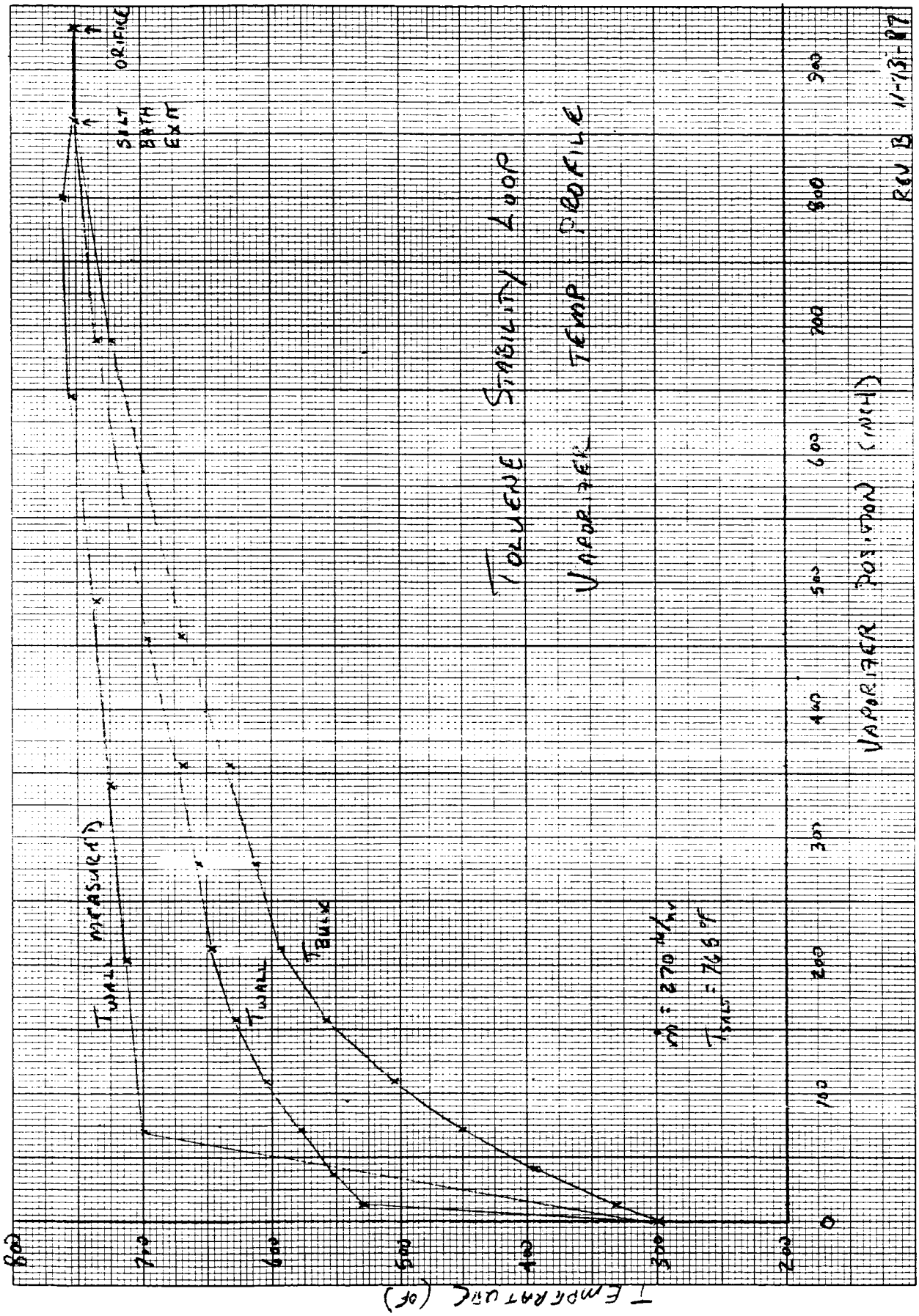
ΔQ = Ui*Ai*ΔT Ai = (ΔQ/Ui*ΔT) = 9212.5/(Ui*ΔT)

hi (BTU/HR-FT2-R)	Ui (BTU/HR-FT2-R)	ΔT (DEG-F)	Ai (FT2)
202.1	191.6	198	0.243
223.8	211.0	158	0.276
242.5	227.6	126	0.321
258.1	241.3	98	0.390
284.6	264.3	71	0.491
325.2	298.9	53	0.582
348.4	318.4	44	0.658
365.4	332.6	36	0.769
322.0	296.2	27	1.152
315.6	290.8	10	3.168
			8.05 FT2 *

* (ACTUAL AREA = 7.88 FT2)

PLOT PROFILE

POSITION OF SEGMENT END (IN)	AVERAGE POSITION (IN)	AVERAGE BULK TEMP(F)	AVERAGE WALL TEMP(F)
0.0		300	300
	13	331	529
25.9			
	41	393	551
55.3			
	72	450	576
89.5			
	110	505	603
131.1			
	157	557	628
183.4			
	214	593	646
245.5			
	280	612	656
315.6			
	357	632	668
397.6			
	459	670	697
520.4			
	689	723	733
858.1			
927.0		750	750



Appendix B - Calculations to Predict Gas and Liquid Degradation

VAPOR PROFILE

END POSITION (IN)	0	69	205	340	486	643	800	840	927
AVG. POSITION (IN)	35	137	272	413	565	721	820	884	
TWALL (DEG-F)	530	610	655	685	715	735	745	750	
TBULK (DEG-F)	380	530	610	660	700	730	745	750	
VOLUME (IN3)	10.0	19.7	19.6	21.2	22.8	22.8	5.8	11.0	
DENSITY(LB/FT3) (TBULK @ 600PSI)	42.9	35.5	18.0	7.4	6.5	6.0	5.9	5.8	
MASS (GRAMS)	115	184	92.7	41.2	39	36	9	17	
(LBS)	.25	.41	.20	.091	.086	.079	.020	.037	

This section derived from section 2.4 of Reference 18.

Numerous isothermal capsule degradation tests of various fluids have shown that the degradation rate is adequately represented by an equation of the form:

$$R = (a)*\exp(T/\text{gamma})$$

where

R is the degradation rate in weight percent/hour
a is an emperical constant
T is the fluid temperature in degrees F
gamma is the reciprocal slope of R vs T on a semi log plot

The attached isothermal capsule results yield:

a = 1.61 E-13 (wt%/hr)
gamma = 3.11 E+01 (wt%/hr-F)

Since the flow in the heater tube is turbulent and the one-seventh law approximately defines the velocity profile, a modified one-seventh law will be used to define the bulk fluid temperature profile.

$$Tr = Tw - (\text{alpha})*(1 - (r/ro))^{(11/7)}$$

where alpha = constant

Now, since a bulk fluid degradation is to be found, a bulk fluid temperature is necessary:

$$Tb = Tw - (\text{alpha})/(PI*ro^2)\int_0^{r_o}[1 - (r/ro)]^{(1/7)}\, d(PI*r^2)$$

where PI = 3.14159

Setting PHI = [1 - (r/ro)] and integrating

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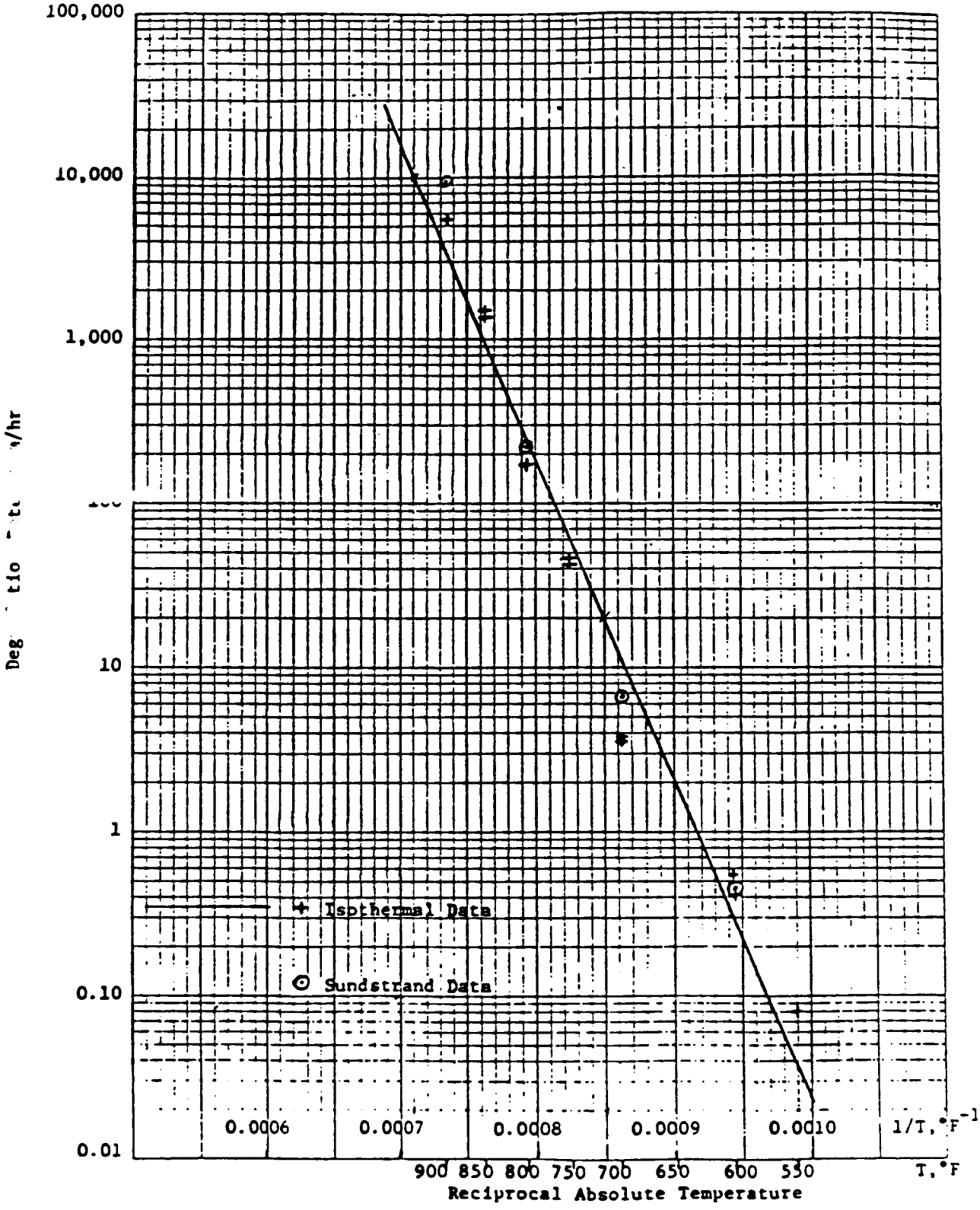

Figure Isothermal Data Compared to Sundstrand Data

$$Tb = Tw - 2*(alpha)*[(7/8) - (7/15)]$$

Hence $alpha = 1.25*(Tw - Tb)$ (approximately)

Thus $Tr = Tw - 1.25*(Tw - Tb)*[1 - (r/ro)]^{(1/7)}$

Now to obtain an average degradation at a cross section in the heater, calculate R.

$$\overline{R} = (1/Pi*ro^2) \int_0^{r_o} a*[\exp(Tr/gamma)]*(2*Pi*r)dr$$

Letting $x = (r/ro)$

$$\overline{R} = 2*a \int_0^1 \exp\{(1/gamma)*[Tw-1.25*(Tw-Tb)*(1-x)^{(1/7)}]xdx$$

Substituting $\phi s = (Tw/gamma)$ and $\phi b = (Tb/gamma)$

$$\overline{R} = 2*a \int_0^1 x*\exp[\phi s - 1.25*(\phi s-\phi b)*(1-x)^{(1/7)}]\, dx$$

Letting Y = the above integral

$$\overline{R} = 2*a*Y$$

Y has been solved for various values of ϕs and ϕb and the results are presented graphically in figures 3 and 4.

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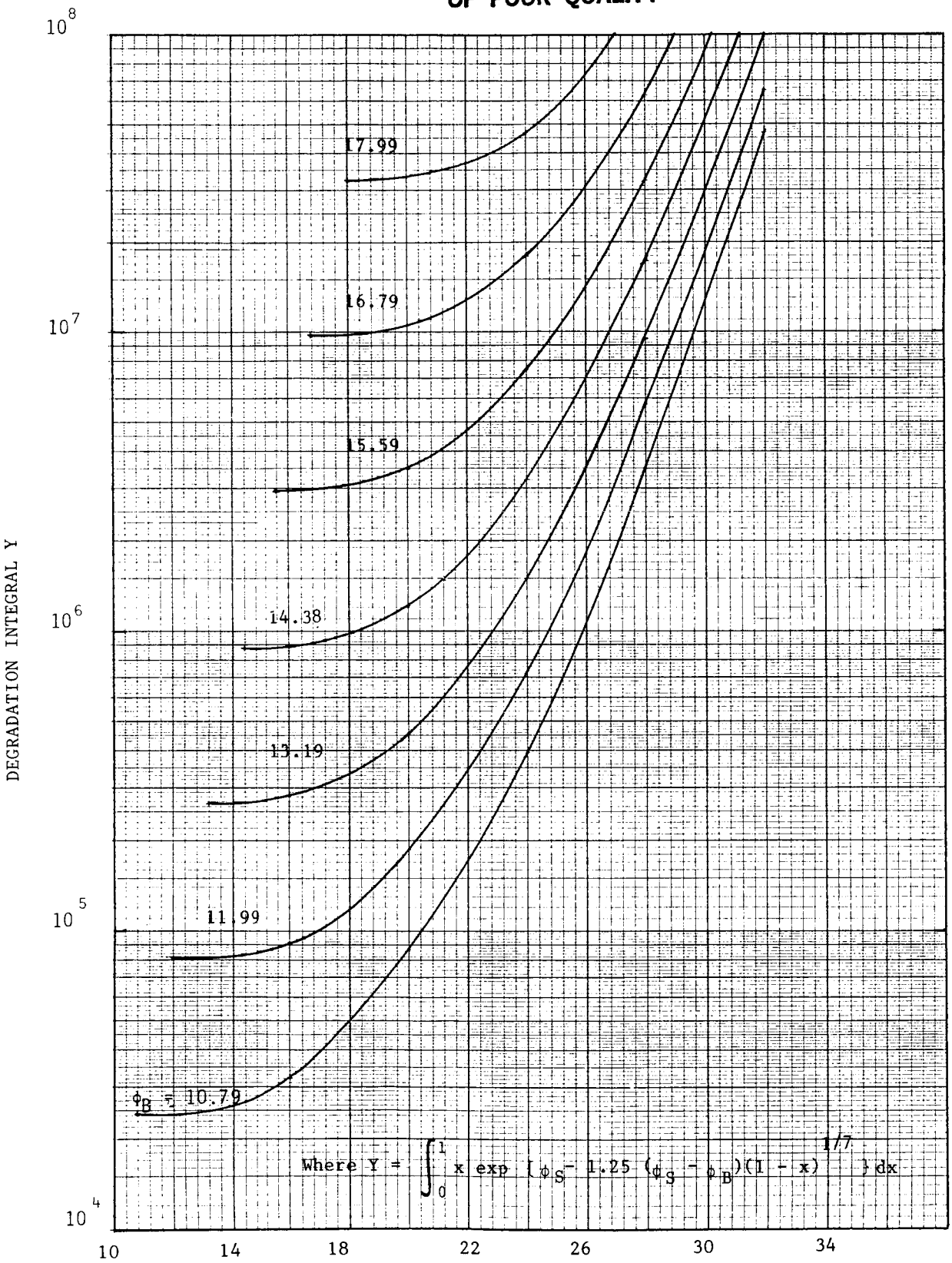

Figure B2

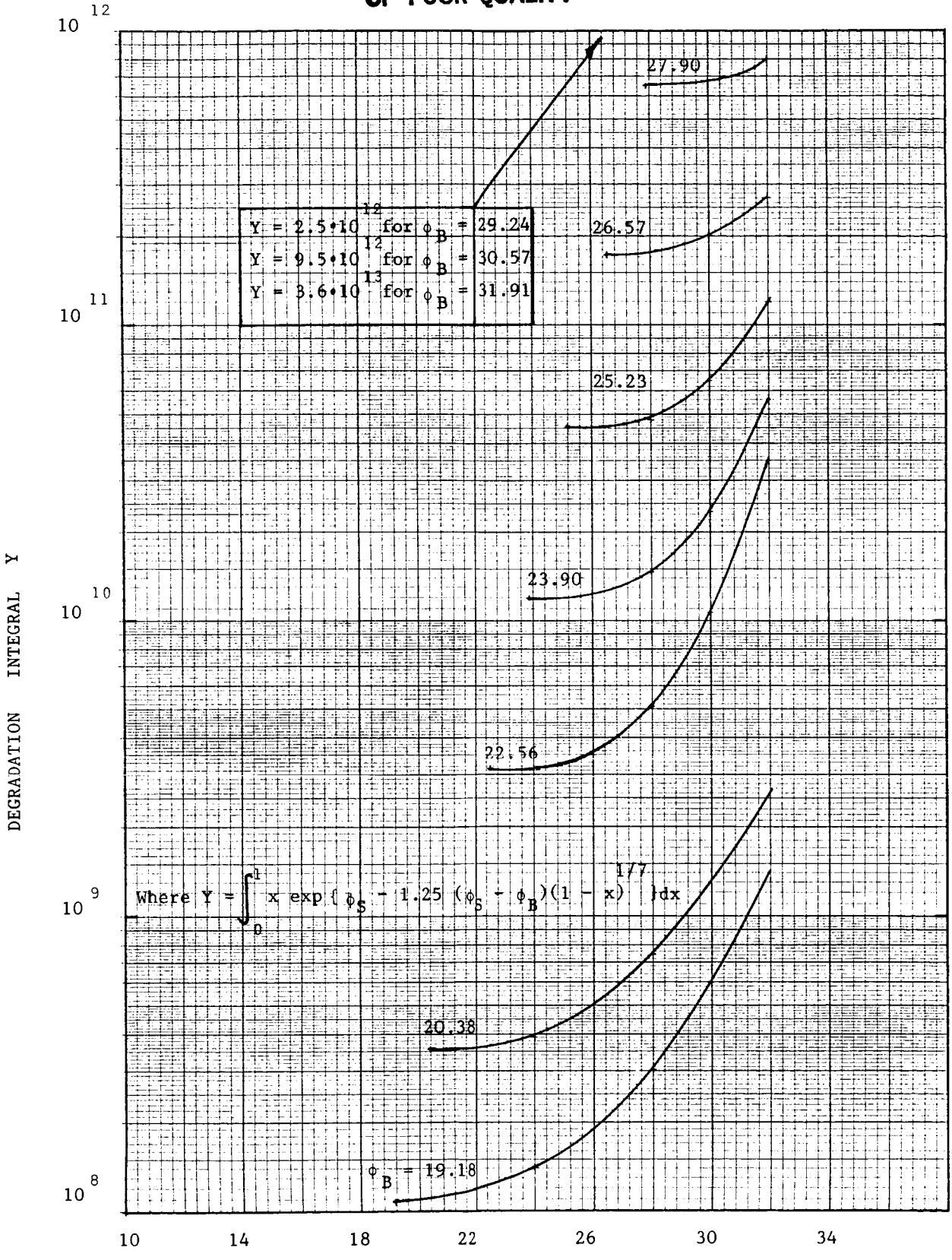

Figure B3

LIQUID DEGRADATION FACTOR Y

ϕ = (T/gamma)

gamma = 31.15

Tbulk	ϕbulk	Twall	ϕs	Y(from figs B2 & B3)
380	12.20	530	17.01	1.2E+05
530	17.01	610	19.58	1.2E+07
610	19.58	655	21.03	1.6E+08
660	21.19	685	21.99	1.0E+09
700	22.47	715	22.95	3.0E+09
730	23.43	735	23.59	8.0E+09
744	23.88	746	23.88	1.3E+10
750	---	750	---	--- *

* NO SIGNIFICANT RADIAL TEMPERATURE DISTRIBUTION.

DETERMINE LIQUID DEGRADATION RATE

R = 2*a*Y R = a*exp(T/tau)

a = 1.61E-13 weight%/hour

Y (non-dim)	R (wt%/hr)	M (grams)	M*R x (1.0 E-02) (grams non-tol./hr)	
1.2E+05	3.86E-08	115	4.40E-08	
1.2E+07	3.86E-06	184	7.10E-06	
1.6E+08	0.51E-04	92.7	4.80E-05	
1.0E+09	3.22E-04	41.2	1.32E-04	
3.0E+09	9.65E-04	39.0	3.76E-04	
8.0E+09	25.73E-04	36.0	9.26E-04	
1.3E+10	41.81E-04	9.0	3.76E-04	
--*	45.91E-04	17.0	7.80E-04	
			2.65E-03	total

0.00265 grams non-tol./hour

* T = 750 DEG-F.
Use R = a*exp(T/tau)

DETERMINE GAS FORMATION RATE

ϕ = (T/gamma)

gamma = 28.01 scc/gm-hr-F *

Tbulk	bulk	Twall	ϕs	Y
380 F	13.57	530 F	18.92	5.2E+05
530	18.92	610	21.78	8.0E+07
610	21.78	655	23.38	1.5E+09
660	23.56	685	24.45	8.0E+09
700	24.99	715	25.53	3.5E+10
730	26.06	735	26.24	1.1E+11
744	26.56	746	26.63	1.7E+11
750	---	750	---	---

* Constants "gamma" and "a" are from attached isothermal data presented in figure B4.

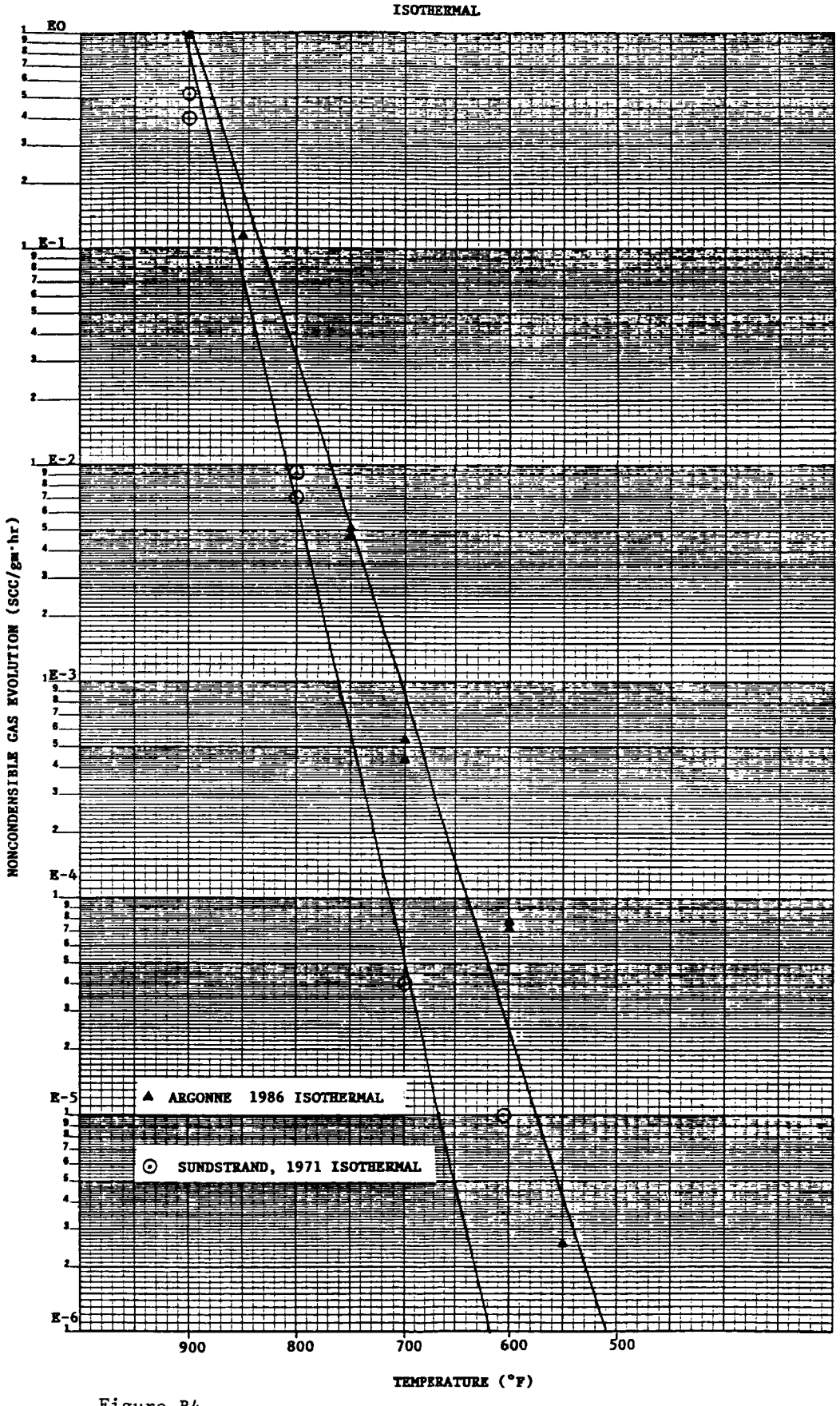

Figure B4

DETERMINE GAS FORMATION RATE

a = 1.22E-14 gamma = 28.01

Y	M (grams)	R = 2*a*Y*M (scc/hour)
5.2E+05	115	1.46E-06
8.0E+07	184	3.59E-04
1.5E+09	92.7	3.39E-03
8.0E+09	41.2	8.04E-03
3.5E+10	39.0	3.33E-02
1.1E+11	36.0	9.70E-02
1.7E+11	9.0	3.70E-02
--(T=750)	17.0	8.70E-02
		0.266 scc/hour

Appendix C - Fluid Inventory History

TOLUENE STABILITY LOOP INVENTORY HISTORY

FILLED LOOP		+35.5 lbs
PRIOR TO DAMPER FAILURE		-3.8
Removed filter	300 ml	
Particle count	100 ml	
NVR	1000 ml	
Liquid ring pump ("1/2 inch drop in sightglass")	600 ml	
DAMPER FAILURE		??
RECHARGED LOOP		+10.0
PRIOR TO ZERO HOURS		-4.6
Particle count	100 ml	
NVR x 2	2000 ml	
Gas sample	300 ml	

GAS SAMPLES

NOTE: 125 cc BOTTLE = 180 cc
250 cc BOTTLE = 315 cc

HOURS	MEASURED BUBBLE VOLUME (SCC)	ESTIMATED LIQUID VOLUME (SCC) *	LIQUID WEIGHT
0 *	9	300	
20 *	7	300	
45 *	22	280	
165	43	90	
234	39	90	
296	19	140	
440	17	140	
512	13	150	
631-1	11	160	
631-2	7	160	
800	17	140	
938	37	90	
1071	19	140	
1446	22	130	4100 ml =
1713	7	160	7.8 lbs
2001	45	90	
2168	30	120	
2550	32.4	120	
2996	40	90	
3164	large	50	
3189	large	0	
3212 *	large	510	
3335	large	270	
3356	large	90	
3362	large	0	
3380	large	0	
3381	3	170	
3400	60	120	

* 250 cc bottle where noted; otherwise 125 cc bottle

LIQUID SAMPLES

NVR TAKEN @ 23 HOURS

ALL LIQUID SAMPLES WERE 40 ML EXCEPT ONE (1)

40 ML SAMPLES

SUNDSTRAND	15
ARGONNE	2 *
LeRC	2

150 ML SAMPLE @ HOUR 2996
SPLIT BY SUNDSTRAND AND ARGONNE

1000 ML + 19*(40 ML) + 1*(150 ML) = 1910 ML = 3.6 LBS

* FOUR SAMPLES WERE SENT TO ARGONNE. ZERO HOUR WAS FROM BARREL; (2) 40 ML SAMPLES AND (1) 150 ML SAMPLE.

RESIDUAL LIQUID LEFT IN VALVE TEE

ESTIMATE TEN (10) INCHES OF 1/4 IN OD TUBING. THEREFORE 4.2 ML LOST FOR EVERY SAMPLE.

GAS SAMPLES * -- 34
LIQUID SAMPLES * -- 20

54*(4.2 ML) = 227 ML = 0.4 LBS

* TOTAL SAMPLES REMOVED--INCLUDING SAMPLES SENT TO OFF-SITE LABS AND THOSE LOST IN HANDLING.

SUMMARY

FILLED LOOP	+35.5
SAMPLES PRIOR TO DAMPER FAILURE	-3.8
DAMPER FAILURE	??
RECHARGED LOOP	+10.0
SAMPLES PRIOR TO ZERO HOURS	-4.6
GAS SAMPLES	-7.8
LIQUID SAMPLES	-3.6
LOST IN VALVE TEE DURING EVACUATION	-0.4

PREDICTED INVENTORY = (25.3 LBS) - (LOST IN DAMPER FAILURE)
@ END OF TEST

THEREFORE THIS IS NOT GOING TO TELL ME ANYTHING.
TRY A DIFFERENT APPROACH.

WORK BACKWARDS TO DETERMINE LOOP INVENTORY AT ZERO HOURS

INVENTORY COLLECTED AT END OF TEST	8.9 LBS
ESTIMATED RESIDUAL INVENTORY NOT COLLECTED AT END OF TEST	+1.0
LIQUID LOST IN VALVE TEE DURING EVACUATION	+0.4
GAS SAMPLES	+7.8
LIQUID SAMPLES	+3.6
	21.7 LBS AT START OF TEST

PREDICTIONS OF DEGRADATON BASED ON CAPSULE TESTS

GAS

CALCULATED TEMPERATURE PROFILE

PREDICTION IS INDEPENDENT OF INVENTORY.

MEASURED = 0.07 scc/hour
PREDICTED = 0.27 scc/hour

LIQUID

CALCULATED TEMPERATURE PROFILE

PREDICTION IS DEPENDENT ON INVENTORY.

CALCULATION ENDS UP WITH A VALUE FOR GRAMS OF NON-TOLUENE FORMED IN VAPORIZER PER HOUR.

0.00265 (gram non-tol.)/hour

TO GET TO WEIGHT PER-CENT PER HOUR, DIVIDE BY WEIGHT OF INVENTORY.

10 LB INVENTORY	--- 4.5E-05	WGT%/HR	(EOL)
20 LB INVENTORY	--- 2.3E-05	WGT%/HR	(BOL)
MEASURED RATE (CURVE FIT)	--- 2.8E-05	WGT%/HR	

COMPARISON OF LOOP DEGRADATION TO PREDICTIONS

BASIS OF COMPARISON IS ON:
GRAMS OF NON-TOLUENE FORMED PER HOUR IN VAPORIZER
(NOT WEIGHT PER-CENT)

THIS IS INDEPENDENT OF AMOUNT OF FLUID INVENTORY.

MEASURED RATE IS CALCULATED OVER PERIOD FROM:

187 HOURS TO 2996 HOURS, INCLUSIVE

(GRAMS FORMED) = (GRAMS IN FLUID @ EOL) +
(GRAMS REMOVED) -
(GRAMS AT START)
= (19.45) + (4.38) - (17.00)
= 6.83 GRAMS

MEASURED RATE = (6.83)/(2996-187) = 0.00243 GRAMS/HR

MEASURED RATE = 0.00243 GRAMS NON-TOLUENE/HOUR
PREDICTED RATE = 0.00265 GRAMS NON-TOLUENE/HOUR

GRAMS OF NON-TOLUENE IN STABILITY LOOP

HOURS	MEASURED NON-TOLUENE (WGT %)	CALCULATED FLUID INVEN-TORY**(LBS)	FLUID REMOVED BETWEEN SAMPLES (LBS)	GRAMS NON-TOLUENE * (GRAMS)
0	0.163	21.70		
			3.86 @ 0.163 %	2.86
187	0.210	17.84		
			0.79 @ 0.210 %	0.75
512	0.205	17.05		
			1.06 @ 0.205 %	1.00
800	0.223	15.99		
			0.87 @ 0.223 %	0.88
1403	0.208	15.12		
			0.33 @ 0.208 %	0.31
1713	0.231	14.79		
			0.38 @ 0.231 %	0.40
2001	0.254	14.41		
			0.25 @ 0.254 %	0.29
2093	0.250	14.16		
			0.31 @ 0.250 %	0.35
2550	0.280	13.85		
			0.08 @ 0.280 %	0.10
2604	0.265	13.77		
			+0.25 @ 0.265 %	0.30
2996	0.317	13.52		

* NON-TOLUENE GRAMS = (FLUID REMOVED,LBS)*(%CONCENTRATION)* (454 GRAMS/LBM)

** PRIOR TO SAMPLES BEING TAKEN.

ADDITIONAL NOTES

NUMBER OF GRAMS OF NON-TOLUENE IN THE SYSTEM AT 187 AND 2996 HOURS ARE CALCULATED IN THE FOLLOWING MANNER.

(GRAMS OF NON-TOLUENE IN SYSTEM @ 187 HRS) = (AMOUNT OF FLUID IN SYSTEM) X (CONTAMINENT CONCENTRATION)

= (17.84 LBS)*(0.00210)*(453.6 GMS/LB)
= 17.00 LBS

(GRAMS OF NON-TOLUENE IN SYSTEM @ 2996 HRS) = (13.52 LBS)*(0.00317)*(453.6 GMS/LB)
= 19.45 LBS

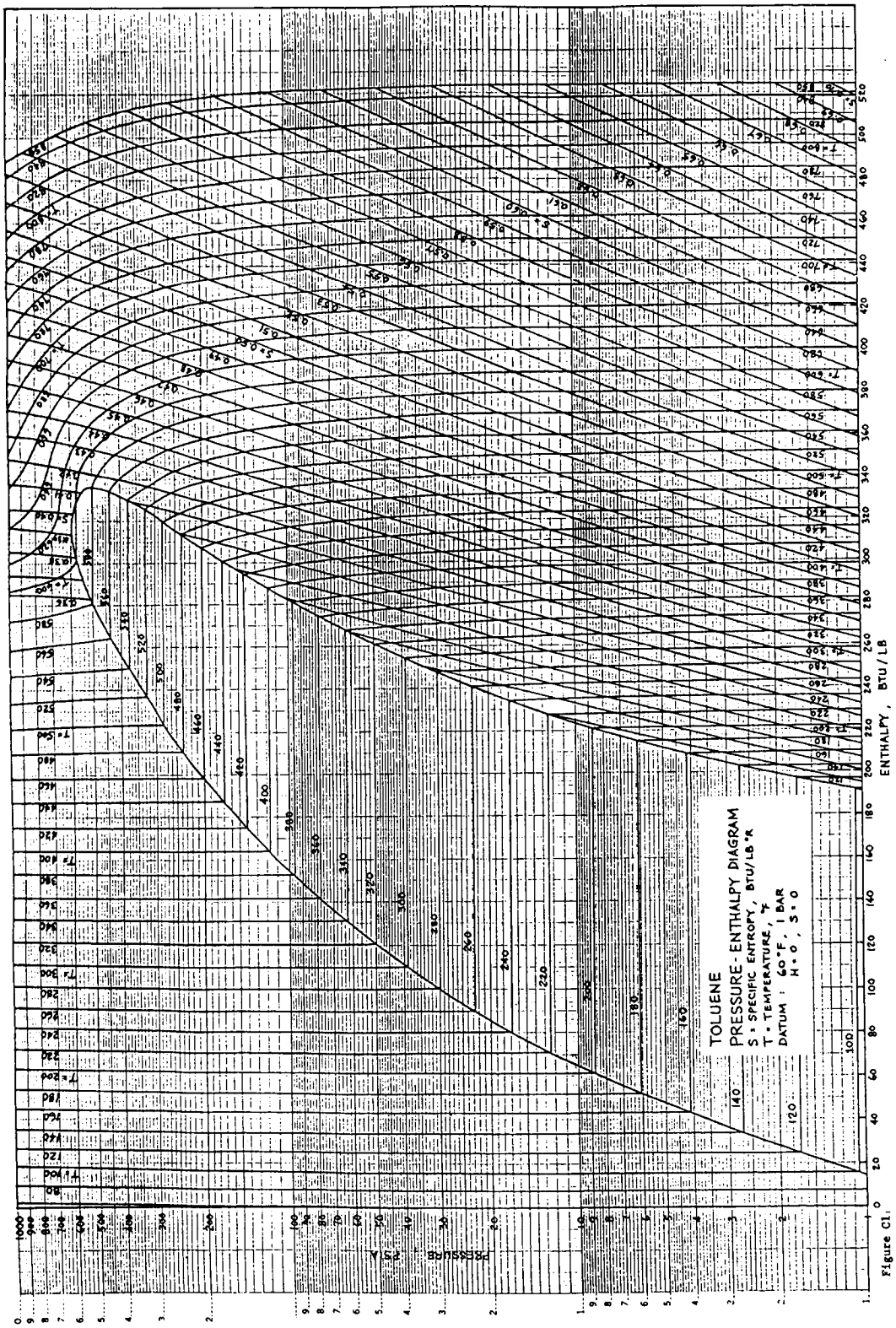

Figure C1.

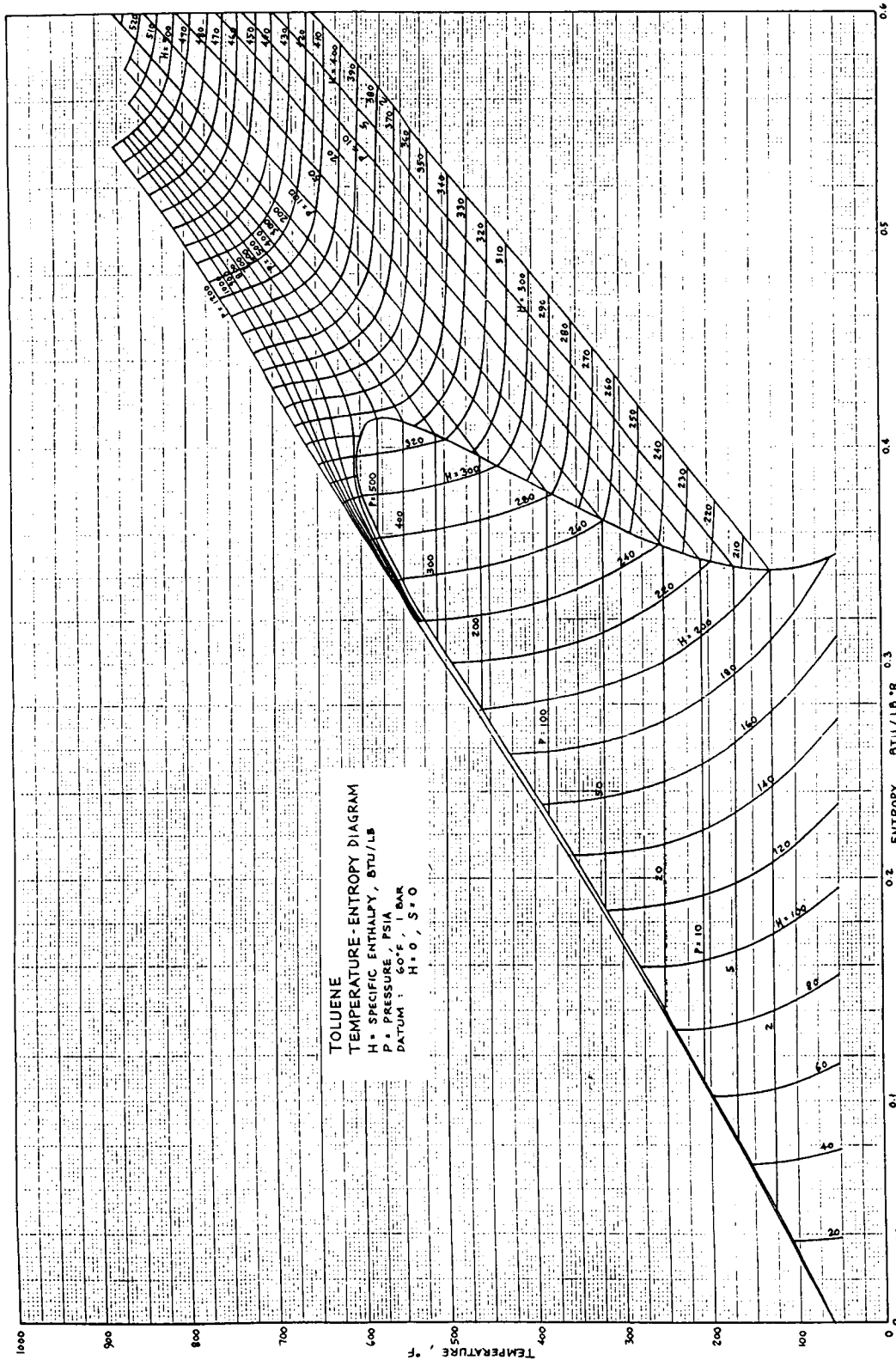

Figure C2

APPENDIX D

Thermodynamic Properties of Toluene and Partially Degraded Toluene After Exposure to 750°F in a Rankine Cycle for Extended Periods of Time

by

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ABSTRACT

Toluene is being considered as a Rankine cycle fluid for space station applications involving exposure to temperatures of about 700°F and pressures of 600 psia. Thermal degradation of the toluene is virtually zero, but some measureable degradation from 0.15% to 0.33% impurity has resulted from 3385 hours of operation as a Rankine cycle fluid at 750°F. Extreme reliability is mandatory in space station applications, and a research program has been completed to determine the effects of degradation impurities on the thermodynamic properties of toluene.

Our results are that a concentration of 0.34% degradation impurities in toluene have negligible effect on the thermodynamic properties of toluene except in the dew point region. In this region, the dew point temperature increases about 20°F at 5 psia and enthalpy or entropy plots versus temperature at constant pressure differ from pure toluene by about 5°F.

We are not in a position to say what effects these might have on the power cycle. But as an off-hand evaluation, we suspect that these differences will not cause problems; because vapor from a cycle using a turbine expander will exit significantly above the dew point temperature. We expect that more detailed evaluations will be made by the Sundstrand Advanced Technology Group.

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INTRODUCTION

Toluene is being studied by the Sundstrand Advanced Technology Group as a Rankine cycle fluid to be used in space station applications where it will be exposed to temperatures of about 700°F and pressures of about 600 psia. Toluene is a very stable compound, but it appears to undergo some thermal degradation over long periods of time. Tests with toluene as a Rankine cycle fluid at 750°F exceeding 3385 hours of operation had been made at Sundstrand before this project was initiated. During this period impurities had built up from an initial concentration of about 0.15% to 0.33%. At these levels, the impurities are sufficiently low that both the original and the partially degraded toluene samples could be considered as reagent grade toluene. Summaries of analyses of the toluene samples after various periods of exposure are summarized in Appendix A. Nevertheless, extreme reliability is needed of any fluid used in space station applications; and Wiltec Research Company has performed a research project under contract with Sundstrand to determine the effect of the degradation products on the thermodynamic properties of the fluid.

RESEARCH PROGRAM

A research program was undertaken to determine the thermodynamic properties of original and partially degraded toluene at temperatures from 150 to 850 degrees F and 5 to 900 psia. Specific properties developed on both samples are as follows:

Entropy as a function of temperature

Enthalpy as a function of pressure

Specific volume/density as a function of temperature

Included in the program was the measurement, evaluation, correlation, and compilation of thermodynamic data in both tabular and graphical form. The measurement program consisted of the following.

Density of Toluene and Partially Degraded Toluene

Figure 1 shows the planned liquid density and PVT points. The conditions are listed below.

Liquid Density of Toluene and Partially Degraded Toluene

18 points per sample; approximately 6 temperatures and 3 pressures:

	Temperature, °F					
Pressure, psia	150	200	300	400	500	600
2000						x
1000	x	x	x	x	x	x
600	x	x	x	x	x	x
Sat'n Pressure	x	x	x	x	x	

PVT of Toluene and Partially Degraded Toluene

12 points per sample; approximately 2 temperatures and 6 pressures:

Pressure, psia	Temperature, °F 600	700	750
2000		x	x
1000		x	x
600		x	x
300	x	x	x
100	x	x	x

These points cover the important regions and provide the needed information for the correlative work.

The planned enthalpy measurement conditions are as follows.

Isothermal Enthalpy of Toluene and Partially Degraded Toluene

6 points per sample; 2 temperatures and 3 pressures.

Pressure, psia	Temperature, °F 150	750
700	x	x
600	x	x
100	x	x

Isobaric Enthalpy of Toluene and Partially Degraded Toluene

12 points per sample; 2 pressure and 6 temperatures.

Pressure, psia	Temperature, °F 150	300	400	500	600	750
600	x	x	x	x	x	x
15	x	x	x	x	x	x

The isothermal enthalpy measurements were to be made from the pressure indicated in the table down to approximately atmospheric pressure in each case. This pressure is slightly higher than 5 psia which is the low pressure limit of interest. However, because of the verticality of the isothermal paths in this region, there was no problem with extrapolating to 5 psia.

The low-pressure isobaric measurements were planned at about atmospheric pressure in order to correspond to the isothermal measurements and to avoid some time-consuming experimental difficulties associated with vacuum operation. Again there was no trouble with extrapolating to 5 psia.

Entropy data are difficult to measure experimentally because thermodynamic engines operating as a Carnot cycle with 100% efficiency do not appear to exist. As an alternative, entropy is nearly always calculated from other thermodynamic properties such as the following:

$$dS = \frac{dH}{T} - \frac{V}{T}\,dP \qquad (1)$$

$$dS = \frac{dU}{T} + \frac{P}{T}\,dV \qquad (2)$$

Thus at constant pressure:

$$S = S^\circ + \int_{T^\circ}^{T} \frac{dH}{T} \qquad (3)$$

While at constant volume:

$$S = S^\circ + \int_{T^\circ}^{T} \frac{dU}{T} \qquad (4)$$

These are examples where it is necessary to integrate enthalpy or energy data in order to obtain entropy. This need for integration or in some cases differentiation of other data seems to be the most reliable method of determining entropy. Accordingly, the density and enthalpy measurements outlined above were chosen so as to favor the development of entropy data along with the other properties.

A subsequent step to the measurement program was the evaluation, correlation, and compilation of the desired thermodynamic data. Evaluated and correlated data included both measured and literature data on the following properties:

1. Vapor pressure
2. density and PVT data
3. heat capacity data
4. enthalpy and latent heat data

Data were selected from available data which appear to be reliable by comparison with other literature data and by thermodynamic consistency tests. These data were then used to establish a thermodynamic model from which all of the thermodynamic properties could be calculated and compiled.

Tables of the thermodynamic properties of toluene and partially degraded toluene are attached to this report as Appendix B. The tables are organized in the following fashion.

Toluene

1. T-P Table: Gives enthalpy, entropy, volume and density at even values of temperature and pressure in the liquid, vapor and superheat regions.

2. T-s Table: Similar to T-P table with temperature and entropy at even values.

3. P-h Table: Similar to T-P table with pressure and enthalpy at even values.

4. Saturation Table: Gives properties at even values of temperature and liquid-vapor quality in the two phase region.

Partially Degraded Toluene

Tables analogous to those for toluene.

Also attached as part of Appendix B are fold-out P-h and T-s diagrams of toluene. Similar figures for partially degraded toluene were not prepared because they would be visually identical.

The tables and diagram for toluene are based on pure toluene with zero impurities. The tables for partially degraded toluene are based on sample analyses given in Appendix A at 3385 hours

which were lumped as follows:

Compound	No. of Carbon atoms	ppm by wt	ppm by moles
Benzene	6	219	258
Cyclohexane	6	300	329
Ethyl benzene	8	477	414
p-xylene	8	713	619
diphenylmethane	13	498	273
C_1 diphenylmethane	14	653	330
bibenzyl	14	580	293
Total impurity		3440 wt ppm or 0.3440 wt%	2516 mole ppm or 0.2516 mole %

This analysis is consistent with our most sensitive physical property measurement which was liquid density where the difference in deviation errors between pure toluene and partially degraded toluene are about $\pm$0.03% while the difference in calculated density is also about $\pm$0.03%. This precision does not represent confirmation of the analysis, but it does indicate that the analysis is probably in the right ball park.

Even though the derived thermodynamic properties of the partially degraded toluene differ very slightly in the regions of measured data, the dew point region is quite sensitive to these trace impurities. This is shown in Figure 2 where at 5 psia the difference between the dew point and bubble point pressures is about 20°F. This could be a problem if there are regions in the Rankine cycle where even traces of condensate might cause

problems. Off-hand we do not believe it to be a problem at least so far as turbine expansion is concerned because a nearly isentropic decrease in pressure from a region which misses the two-phase dome at high pressure will be farther from it at low pressures, thus reducing the chance that any condensate would form. If the question of dew point is not a problem, then the maximum difference between the T-h plots of the two fluids at 5 psia is about 5°F in the region of the dew point of pure toluene. This is shown in Figure 3 where T-h curves are plotted in the dew point region for both fluids. Analogous features appear on the T-s plots because at constant pressure ds = dh/T. At higher pressures the differences get smaller because the separation between the dew point and bubble point curves in Figure 2 gets smaller. Thus the effect of heavy impurities is most prominent in the dew point region of the fluid and is largest at low pressures where the dew points differ by about 20°F and enthalpies or entropies differ by about 5°F.

CORRELATION MODEL

A powerful method for the correlation of thermodynamic data involves the use of a parent function for one of the free energy functions. The logical choice is the Helmholtz free energy because it can be calculated by integrating the usual equation of state giving pressure as a function of volume.

$$A = - \int P dV + f(T,n) \qquad (5)$$

where f(T,n) is the integration constant independent of volume.

The function f(T,n) involves the entropy of mixing of an ideal gas which is known and the ideal gas heat capacity which is generally known.

The basic feature of this correlation method is that one can calculate all of the thermodynamic properties of a fluid from one unique function; thus insuring thermodynamic consistency between all of the derived properties with a minimum of correlation parameters.

The model chosen for the current project is the extended corresponding states model of Lee and Kesler (1975) which involves a modified BWR equation of state. An outline of the model is given in Table 1 where Z-factors, enthalpy, entropy, and fugacity are calculated by standard corresponding states procedures with the acentric factor as the third parameter. The

method involves the use of mixing rules for the definition of T_r, P_r, and ω of mixtures based on analogous properties of each pure material. Table 2 summarizes these pure component data and the ideal gas heat capacity constants of the various real components or assumed pseudo components of the mixtures.

The model of Lee and Kesler is based on the properties of methane and n-octane, and one would not expect toluene to correspond exactly to a material intermediate between methane and octane because they are paraffins with no unsaturation while toluene contains an aromatic ring with considerable unsaturation. Thus it was not surprising to find that adjustments in the model were necessary in order to represent the properties of aromatic compounds like toluene. A description of these adjustments is given in Table 3.

The advantage of using the Lee-Kesler model with minor adjustments is that it allows one to extrapolate or interpolate over a wide range of conditions without significant loss in accuracy. A single equation of state fitted to the experimental data on toluene would probably fit the data better than is achieved here with the Lee-Kesler model. But in doing such close fitting one would also introduce opportunities for large interpolation and extrapolation errors due to divergence in regions which are not fitted. The Lee-Kesler model also allowed an initial assessment of available data to determine consistency between sets of data.

MEASURED DATA

Measured data on toluene and partially degraded toluene are given in Tables 4 to 12 as follows:

Samples	Data	Table
Toluene	Liquid Density	4
Toluene	Vapor and Superheat Densities	5
Degraded	Liquid Density	6
Degraded	Vapor and Superheat Densities	7
Toluene	Isobaric Enthalpy, 0.885 Bar	8
Toluene	Isobaric Enthalpy, 41.5 Bar	9
Degraded	Isobaric Enthalpy, 0.886 Bar	10
Degraded	Isobaric Enthalpy, 41.5 Bar	11
Both Samples	Isothermal Enthalpies	12

These data were not correlated in developing the thermodynamic models of toluene and partially degraded toluene, so comparisons with these data provide a good indication of the reliability of the models in non-correlated regions. The results can be summarized as follows:

Sample	Data	RMS Error	Excluded no. of Points
Toluene	Liquid Density	0.4%	2
Toluene	Vapor and Superheat Density	0.7%	1
Degraded	Liquid Density (continued)	0.4%	1
Degraded	Vapor and Superheat Density	0.5%	2
Toluene	Isobaric Enthalpy, 0.885 Bar	0.6 KJ/mole	2
Toluene	Isobaric Enthalpy, 41.5 Bar	0.8 KJ/mole	1
Degraded	Isobaric Enthalpy, 0.896 Bar	0.9 KJ/mole	0
Degraded	Isobaric Enthalpy, 41.5 Bar	0.9 KJ/mole	0
Toluene	Isothermal Enthalpy	0.2 KJ/mole	0
Degraded	Isothermal Enthalpy	0.2 KJ/mole	0

The enthalpy errors can probably be best evaluated in terms of heat exchanger duty which is mainly latent heat affects. Thus, at 5 psia the heat of vaporization of toluene is 35.28 KJ/mole (Appendix B), so an error of $\pm$0.8 KJ/mole represents an error of about $\pm$2% in the heat exchanger duty for condensation of toluene at this pressure. The thermodynamic model is probably better than this because agreement with literature data in the next section of this report on heats of vaporization show an RMS error 0.22%. Thus much of the $\pm$0.2 to $\pm$0.8 KJ/mole RMS error in tables 8 to 12 is presumably measurement error. Given more time

in the laboratory, one could probably improve on the accuracy of these measured data down to about ±1% or ±0.4 KJ/mole.

We note that RMS deviations between measured and calculated data in Tables 4 to 12 exhibit about the same error for corresponding points in each table. Thus, there does not appear to be any error in modeling the partially degraded toluene that didn't also exist in modeling pure toluene. A good example of this is the liquid density of toluene versus partially degraded toluene in Tables 4 and 6 respectively. The RMS error for both sets is 0.4%; but as is shown in Table 6, the difference between deviations of corresponding points in the two tables is about ±0.03% for most of the points. This shows that the properties are essentially the same or that our modeling properly takes into account the effect of impurities. In actual fact, both contribute to the net result.

LITERATURE DATA

Principal literature references pertaining to the thermodynamic properties of toluene are given in Table 13. Of these, we consider the most significant work to be that of Akhundov and Abdullaev (1970) who measured precise density, PVT, and vapor pressure data on toluene at temperatures from 25 to 400°C and 0 to 500 bars. Their data are the most complete single set of data on toluene, and the precision or accuracy of their data is in good agreement with other published data over narrower ranges of conditions. For this reason, our modeling has been done with primary emphasis on their work.

Table 14 gives a comparison of calculated data from the model versus the work of Akhundov and Abdullaev. Our RMS error in fitting their data is $\pm$0.24% excluding 6 points which deviate more than 1.3%. Other literature data on density are the results of Hales and Townsend (1972) for liquid densities summarized in Table 15. The RMS error of $\pm$0.18% between calculated and measured data gives an indication of the prediction accuracy of the model because these data were not correlated. Figure 4 shows a plot of deviations of liquid density data where excellent agreement is shown throughout. Figure 5 gives a similar comparison in the vapor or super heat regions. This plot shows that the only available data are measurements of this project and the work of Akhundov and Abdullaev. Deviations are larger than in the liquid region, but good agreement is shown between our

work and their work.

Comparisons were also made with density and PVT properties given in the TRC Thermodynamic Tables (1986) just to see how their model compares with our model. Table 16 gives a comparison of calculated values from our model with their tabulated liquid densities where the RMS error is ±0.29% (excluding two points). This is a larger RMS error than we have in fitting all of the data of Akhundov and Abdullaev of ±0.24% plus the work of Hales and Townsend of 0.18%. Thus we believe we have a better fit to the available data. In the vapor and superheat regions compared in Table 17 the TRC tables compare very poorly with deviations as large as 45%. Thus, in some regions of superheat their tables appear to be in gross error. This is quite disappointing because the scientific community normally accepts the TRC tables as the best available. This comparison shows that one probably should be more cautious.

Table 18 gives comparisons between calculated and literature vapor pressure data on toluene. Only one parameter in the model, the acentric factor of toluene, was adjusted to fit the vapor pressure data. Deviations in data considered to be accurate are plotted in Figure 6 where a smooth curve could be drawn through data from six different sources with an RMS error of 0.26%. At high temperatures, the data of Ambrose et al. (1967) are in very good agreement with the data of Akhundov and Abdullaev. No other high temperature vapor pressure data were found. Nevertheless, the agreement between these two sets of data fairly well

establishes the vapor pressure of toluene at high temperatures. Table 19 shows that there is also good agreement with the TRC tables at low temperatures where the RMS error is 0.28%.

Comparisons of calculated versus experimental densities, PVT properties, vapor pressures, and latent heats only test the adequacy of equation of state parameters without the need for ideal-gas heat capacity data. Nevertheless, the equation-of-state effects are very large; and these comparisons give a very good test of these parameters. The calculated heat of vaporization of toluene is compared with literature data in Table 20 and Figure 7 where the RMS error is 0.22%. These data were not correlated, thus the agreement shown here shows that the model is quite reliable.

Heat effects which do involve the ideal gas heat capacities are those where a temperature change occurs. This includes liquid and or vapor heat capacities, and associated enthalpy changes. The ideal gas heat capacity is generally known quite accurately from spectroscopic data. Data for toluene based on both spectroscopic and calorimeter data are given by Scott et al. (1962) over a very wide range of temperatures. We have used their values without modification. However, we note that Rudolph (1967) comments that spectroscopic data are in conflict with calorimeter data on toluene. From our experience, the spectroscopic data are usually much more precise than calorimeter data; but Scott et al. suggest that they are in harmony. We wonder how they weighed the two sources in developing their ideal

gas tables.

The combined effects of ideal gas heat capacities and effects from molecular interactions are normally studied by means of calorimetry. However, these measurements by calorimetric methods are difficult due to the requirement of heavy walls to contain pressure at elevated pressures and heat leak problems associated with high temperatures. Thus very few data exist on these properties at the conditions of interest for toluene. Available literature data are compared in Tables 21 and 22 while data of this project are given in Tables 5 to 12. Figure 8 gives a comparison of these data in the liquid region at high temperatures. The accuracy of these data is less than for other properties. Nevertheless, data in these tables do not suggest any modification of the ideal gas heat capacity. Perhaps most significant are low pressure data at high temperatures of this project given in Table 8 where calculated data deviate both above and below the measured data. Also, the RMS error of $\pm$0.6 KJ/mole can be interpreted as the uncertainty in the ideal gas heat capacity. The percentage uncertainty would than be the uncertainty divided by the enthalpy difference between the lowest and highest temperatures. From Table 8 the difference is about 50 KJ/mole, so the uncertainty in the ideal gas heat capacity is $\pm$0.6/50 or $\pm$1.2% based on comparisons with the measured calorimeter data. This agreement seems quite satisfactory when consideration is made for the calorimeter accuracy of about the same magnitude.

Density Measurements

The density measurements reported in Tables 4 and 6 were made in the apparatus shown in Figure 9. The volume of the stainless steel cell was measured using water at 65, 165, 265, 365, 465, 565, 605 °F and at pressures from the steam point to 2000 psia. These measured water densities were compared to values in the NBS Steam Tables, Haar et al.(1984). This facilitated accurate temperature and pressure dependent volume calibration to ±0.01 cc. The cell volume at 75°F was 150.34 cc. The sample cell was first filled with the sample and weighed to verify both the density and that no gas bubbles were entrained within the sample cell. The sample cell was placed within an electrically heated cast aluminum sleeve which fit snugly around the cell. This aluminum sleeve assured isothermal conditions. The aluminum casting was well insulated and placed on a rocker which tilted the sample through a 75 degree arc at one cycle per second. This agitation was also to insure constant temperature conditions. Pressures were read by means of a calibrated 3-D Instruments precision pressure gauge to ±0.1%. Two platinum resistance thermometers were used in conjunction with a temperature controller to control and record the cell temperature within ±0.03°F of the desired temperature.

The aluminum sleeve was heated electrically to the desired temperature and allowed to stabilize at that temperature for an

hour. The weight of sample in the cell was determined from the weight charged minus the weight removed to obtain each measurement condition. For this purpose a syringe was attached to the cell into which the compressed sample was released. It was necessary to remove some of the charge between temperatures to limit the static pressure of the system. Once the temperature had equilibrated more sample was removed into the syringe until the pressure was at the desired measurement condition. The mass of the sample removed was weighed and recorded. With knowledge of the initial sample mass, the amount removed at each condition, and the corresponding temperatures and pressures one can accurately calculate the liquid densities.

Vapor Densities

The vapor density measurements reported in Tables 3and 7 were made in the apparatus shown in Figure 10. The 1000cc cell was connected to a 100cc Ruska positive displacement (piston type) pump which allowed the addition or removal of measured amounts of charge to within $\pm$ 0.01 cc in order to reach the desired measurement pressures. These pressures were read by means of a calibrated 3-D Instruments precision pressure gauge to $\pm$ 0.1%. The volume of the 1000cc cell was calibrated using two methods. First, the volume of the cell was determined at room temperature by measuring the weight of water it would hold at a known density. Second, n-pentane vapor densities were measured at temperatures of 340, 400, 460 °F and compared to the

literature data of Sage and Lacey (1942).

The 1000cc cell was cast in an aluminum cylinder which completely enclosed the cell. The aluminum casting was heated by means of a resistance heater wrapped around the exterior of the casting. The temperature of the cell was measured by two platinum resistance thermometers, one within the cell, and one within the aluminum casting. Once at isothermal conditions the desired pressure was achieved by adding or removing material by means of the Ruska hand pump. Pressure-volume relationships were then recorded by approaching the pressure from both below and above the desired pressure from high pressure. The differences in volume between the ascending and descending pressure approaches generally ranged less than 0.03 cc and were never more than 0.05 cc. The reported vapor densities are based upon the average of the ascending and descending pressure approaches.

Isobaric Enthalpy Measurements

Isobaric enthalpy measurements on toluene and partially degraded toluene were measured in the boiling fluid flow calorimeter shown in Figures 11 and 12. The test fluid (toluene or partially degraded toluene) enters the calorimeter at a known temperature and leaves at a reduced known temperature at constant pressure. The energy evolved due to the change in enthalpy of the test fluid is measured by the amount of trichlorotrifluoroethane (Freon 113) boiled off per amount of test fluid flowing through the calorimeter. The enthalpy change of the test fluid

is calculated as the ratio of trichlorotrifluoroethane flow rate over test fluid flow rate multiplied by the heat of vaporization of liquid trichlorotrifluoroethane. This apparatus was calibrated using water to evaluate the heat of vaporization of Freon 113 as well as establish the amount of heat leak present at different inlet temperatures and test fluid flow rates.

The inlet portion of the apparatus in Figure 11 consisted of a constant-rate syringe pump connected to an inlet heater. For the low pressure runs, an evaporator was connected in between the pump and the heater. The evaporator consisted of a ten foot section of 0.069 inch i.d. tubing packed with -100 mesh nickel shot. The evaporator was coiled and cast into an aluminum block which was heated to a constant temperature sufficient to evaporate the test fluid. The nickel packing ensured that there was no surging or bumping as the test fluid was vaporized. The runs performed at 600 psia were all in the single-phase region and did not require an evaporator. The temperature of the inlet was measured by means of a calibrated thermocouple inserted down the inlet line. This thermocouple was positioned so as to be between the shield and the calorimeter, representing the point where heat lost from the stream would enter the calorimeter instead of the shield. The temperature of the inlet stream was held constant by means of a controller which varied the power to the inlet heater.

The test fluid then flowed into the calorimeter and through a heat exchanger submerged in the Freon 113. The calorimeter was

constructed of copper to decrease internal temperature gradients. The inlet line after it entered the calorimeter was enclosed in an insulated copper jacket so that most of the heat would be released after the test fluid was in the liquid freon in the calorimeter. This prevented the inlet line from superheating the freon vapor as it boiled out of the calorimeter. Nitrogen was allowed to bubble through the freon at approximately 15 cc per minute to add nucleation sites and reduce bumping and superheating.

The calorimeter was insulated and surrounded by a shield submerged in a constant temperature bath. The bath was maintained at the same temperature as the calorimeter to reduce the amount of heat transfer between the calorimeter and the surroundings to a minimum. The test fluid then flowed out of the calorimeter through the outlet line. The temperature of the outlet stream was measured with a thermocouple inserted down the outlet line located half way between the shield and the calorimeter. The Freon 113 vapor produced in the calorimeter left through a 0.402 inch i.d. line and was condensed and collected in a dry ice trap. An external reservoir in the bath supplied additional Freon 113 as it was boiled out of the calorimeter to maintain the freon fluid level constant.

The test fluid was collected in a pressurized stainless steel receiver. The pressure of the system was maintained at 600 psia by connecting the receiver to a large ballast tank filled with nitrogen at the desired pressure. The low pressure runs

were conducted by opening the outlet line to atmospheric pressure. The pressure drop throught the calorimeter was less then 0.1 psi at 600 psia and about 1 psia at atmospheric pressure.

The runs were repeated until at least two and usually three runs repeated to within one per cent. Over-all temperature measurements are accurate to $\pm 1°F$, the pressures were measured to an accuracy of $\pm 0.1\%$, the test fluid flow rates were accurate to $\pm 0.02\%$, and the weight of Freon 113 boiled off was measured to ± 0.04 grams (representing at worst 0.1% of the measured quantity).

Isothermal Enthalpies

Isothermal enthalpies of toluene and partially degraded toluene were measured in a throttling calorimeter shown schematically in Figures 13 and 14. The test fluid, toluene or partially degraded toluene, flowed through the calorimeter and was throttled from the inlet pressure to the outlet pressure by means of a throttling valve located in the center of the calorimeter. Heat was added to the calorimeter by an internal resistance heater to match or compensate for the change in enthalpy of the test fluid due to throttling.

The test fluid flowed through the calorimeter apparatus at a constant rate of 86 and 43 cc/hr $\pm 0.1\%$ from a motorized syringe pump. Before reaching the calorimeter, the test fluid was preheated to run temperature and vaporized if required in a

preheat coil. It was then equilibrated to the calorimeter temperature by passing through a coil which was silver-soldered to the outer copper shield. The shield temperature was controlled by means of a platinum RTD and a programmable temperature controller and was held constant within $\pm$.05°F. The inlet pressure was controlled manually by either of two throttling valves, one inside and one outside the calorimeter. Both the inlet and the outlet pressures were measured using precision pressure gauges with an accuracy of $\pm$0.1%, although the inlet pressure could only be controlled to within $\pm$0.5%. The change in temperature of the test fluid stream was monitored by means of a voltmeter sensitive to $\pm$0.01 microvolts and two 0.020 inch diameter thermocouples inserted into the calorimeter's inlet and outlet lines to a location halfway between the outer shield and the calorimeter.

Two modes of operation of the calorimeter were required in measuring the isothermal enthalpies of toluene and partially degraded toluene. At 150°F a heating effect was observed as the test fluid was throttled from the inlet pressure to the outlet pressure due to a decrease in enthalpy. At 750°F the opposite effect was observed.

For the lower temperature runs the test fluid was throttled using the valve inside the calorimeter until steady state was achieved as indicated by a constant difference in inlet and outlet temperatures. After this temperature stabilized the valve inside the calorimeter was then fully opened and the test fluid

was throttled outside the calorimeter. Heat was added to the calorimeter by the internal resistance heater to simulate the throttling condition until the previously observed temperature difference was again maintained. This heat then represented the heat evolved by the fluid when throttled inside of the calorimeter.

During the 750°F runs, a cooling effect was observed when throttling the test fluid from a high pressure to a low pressure. The test fluid was therefore throttled and heated simultaneously so that the stream entering the calorimeter and the stream exiting the calorimeter were at the same temperature. The power to the internal resistance heater was measured to $\pm$0.01% in both cases and equals the isothermal change in enthalpy.

SUMMARY AND CONCLUSIONS

Toluene is being considered as a Rankine cycle fluid for space station applications involving exposure to temperatures of about 700°F and pressures of 600 psia. Thermal degradation of the toluene is virtually zero, but some measureable degradation from 0.15% to 0.33% impurity has resulted from 3385 hours of operation as a Rankine cycle fluid at 750°F. Extreme reliability is mandatory in space station applications, and a research program has been completed to determine the effects of degradation impurities on the thermodynamic properties of toluene.

Our results are that a concentration of 0.34% degradation impurities in toluene have negligible effect on the thermodynamic properties of toluene except in the dew point region. In this region, the dew point temperature increases about 20°F at 5 psia and enthalpy or entropy plots versus temperature at constant pressure differ from pure toluene by about 5°F.

We are not in a position to say what effects these might have on the power cycle. But as an off-hand evaluation, we suspect that these differences will not cause problems; because vapor from a cycle using a turbine expander will exit significantly above the dew point temperature. We expect that more detailed evaluations will be made by the Sundstrand Advanced Technology Group.

REFERENCES

L. Haar, J. S. Gallaher, and G. S. Kell, NBS/NRC Steam Tables, Hemisphere Publishing Corp. (1984).

B. I. Lee and M. G. Kesler AIChE J., 21 510 (1975).

R. C. Reid, J. M. Prausnitz, and T. K. Sherwood, The Properties of Gases and Liquids Third Edition, Mc-Graw Hill (1977).

B. H. Sage and W. N. Lacey, Ind. Eng. Chem. 34, 730-736 (1942).

Table 1, Lee-Kesler Corresponding States Correlations Using BWR constants for Methane and n-Octane

1. For the equation of state and the constants for the "simple fluid" and the "reference fluid" see Reid et al. (1977); Sec 3-9, pp 50-52[a]; Sec 4-6, pp 81&82; and Sec 5-4, pp 96 and 112.

2. For mixing rules to obtain T_c and P_c of mixtures, the following equations were used which produce essentially Raoult's law for mixing at low pressures:

$$T_c = [\sum_i x_i T_{c_i} (1 + x_i)^{1.5}]/(1+ x_T)^{1.5}$$

$$P_c = [\sum_i x_i P_{c_i} (1 + x_i)^2]/(1+ x_T)^2$$

$$x_T = \sum_i x_i x_i$$

These are not the same rules recommended by Lee and Kesler. This modification was made in order to approximate Raoult's law at low pressures.

3. The Lee-Kesler procedure was used to obtain Z, H°-H, S°-S, and ln(f/P).

4. Vapor pressures and multicomponent phase equilibria were calculated by finding pressures and compositions

where $f_i^L = f_i^V$. For pure compounds, this can be done directly from the Lee-Kesler model. For mixtures, component fugacities were calculated from the following equation:

$$\ln \frac{f_i}{P x_i} = \frac{\partial \sum_j n_j \ln \frac{f}{P}}{\partial n_i}_P$$

or

$$\ln \frac{f_i}{Px_i} = \ln \frac{f}{P} + \left(\frac{\partial[\ln(f/p)]}{\partial n_i}\right)_P$$

The derivatives $\{\partial[\ln(f/P)]/\partial n_i\}_P$ were calculated numerically where:

$$\left(\frac{\partial L}{\partial n_i}\right)_P = \left(\frac{\partial L}{\partial T_r}\right)_P \frac{\partial T_r}{\partial n_i} + \left(\frac{\partial L}{\partial P_r}\right)_P \frac{\partial P_r}{\partial n_i} + \left(\frac{\partial L}{\partial \omega_T}\right)_P \frac{\partial \omega_T}{\partial \omega_i}$$

with $L = \ln(f/P)$

Derivatives were calculated for both phases at the same pressure. The total pressure and the compositions of the phases were then adjusted while maintaining over-all material balance to find conditions where the fugacity of each component was the same in both phases.

a) In some printings of Reid et al. a typographical error exists in the equation for C; it should be

$$C = c_1 - \frac{c_2}{T_r} + \frac{c_3}{T_r^3}$$

Table 2. Component Properties Used in the Calculation Procedure.
Data are from Appendix A of Reid et al (1977)
except as noted in the table.

Ideal Gas Heat Capacity: $C_p^* = a + bT + cT^2 + dT^3$ Cal/g-mole

	Benzene	Cyclo-hexane	Toluene	Ethyl-benzene	P-Xylene	Diphenyl-Methane	Methyl Diphenyl-Methane	C_2 Diphenyl-Methane	Bi-benzyl
a	-8.101	-13.027	-5.817	-10.294	-5.993	-8.433[a]	-6.553[a]	-6.556[a]	-8.436[a]
b	0.1133	0.1460	0.1224	0.1689	0.1443	0.19997	0.21314	0.23615	0.22299
c	-7.206x E-5	-6.027x E-5	-6.605x E-5	-1.149x E-4	-8.058x E-5	-0.84337x E-4	-0.87547x E-4	-0.98025x E-4	-0.94885x E-4
d	1.703x E-8	3.156x E-9	1.173x E-8	3.107x E-8	1.629x E-8	0	0	0	0
Critical Constants									
Mol wt.	78.11	84.16	92.14	106.17	106.17	168.24	182.27	196.29	182.27
T_c, K	562.1	553.4	591.7	617.1	616.2	767	785[b]	797.1[b]	785[b]
P_c, atm	48.3	40.2	40.6	35.6	34.7	29.4	26.11[c]	23.85[c]	26.11[c]
Acentric Factor	0.212	0.213	0.2627[e]	0.301	0.324	0.474[d]	0.486[d]	0.542[d]	0.486[d]

a) Estimated by Benson's method. See R. C. Reid, J. M. Prausnitz and T. K. Sherwood The Properties of Gases and Liquids, 3rd Ed., McGraw-Hill (1977)

b) The critical temperature was estimated in two steps as follows:
   1. Estimate the boiling point: $T_b^2 = 21.200\ n_p + 133850\ n_r$
      where n_p = no.of CH_2 + CH_2 groups
      n_r = no.of aromatic rings
   2. Estimate the critical point by Lyderson's method. See Reid et al, op cit.

c) The critical pressure was estimated by Lydersons method. See Reid et al, op cit.

d) Acentric factors were estimated from the boiling point assumed in a) and the estimated critical point using the Reidel equation where = (c - 5.814)/4.918. See Reid et al, op cit.

e) Adjusted empirically to fit the vapor pressure of toluene.

Table 3, Adjustments Made in the Lee-Kesler Model in Order to Fit the Properties of Toluene.

Two adjustments were made to correct calculated molar volumes and calculated Z-factors, Z=PV/RT, as follows:

Volume:

A volume correction was made according to the following equation:

$$V = V' - c(\rho')$$

where V = corrected volume

V'= volume calculated from Lee-Kesler model at specified T_r, P_r, and x_T

$c(\rho')$= volume correction which was assumed to be a function of density, ρ', calculated from the Lee Kesler model.

$$c(\rho') = 6.28-5.13\rho' + 15.946(\rho')^2 - 17.248(\rho')^3$$

Z-factor:

Both density and temperature dependent Z-factor corrections were used as follows:

$$\Delta Z = \Delta Z(\rho') + \Delta Z(T)$$

where

$$\Delta Z(\rho') = -0.283f\exp(-80f^2)$$

$$\Delta Z(T) = -(16.15 - 0.0335T)(\rho')\exp(-4000/T) \qquad T>482K$$

$$\Delta Z\ (T) = 0 \qquad T<482K$$

$$f = \rho' - 0.255 \text{ with } \rho' \text{ in g/cc}$$

The net result of the volume and Z-factor corrections is the following:

$$Z = Z' - \frac{P[c(\rho')]}{RT} + \Delta Z(\rho', T)$$

$$V = ZRT/P$$

In these corrections, the term for $\Delta Z(\rho')$ is the derivative of an error function expressed in density rather than volume. This term was necessary in order to fit the experimental data at densities near the critical density. Both the volume and the Z-factor corrections are small and represent corrections of about 1 to 2% in calculated densities.

Table 4, Comparison of Calculated and Measured Liquid Density Data of Toluene

Temperature K	Pressure Bar	Density, g/cc Meas	Density, g/cc Calc	Error %
293.15	1.014	0.8669	0.8687	0.21
299.77	0.807	0.8601	0.8624	0.27
338.30	136.860	0.8370	0.8383	0.16
338.30	102.743	0.8340	0.8352	0.14
338.30	69.240	0.8308	0.8320	0.14
338.30	41.867	0.8284	0.8293	0.10
338.30	7.261	0.8251	0.8257	0.07
366.12	136.040	0.8133	0.8129	-0.05
366.12	104.391	0.8101	0.8094	-0.08
366.12	70.275	0.8064	0.8055	-0.11
366.12	41.453	0.8033	0.8020	-0.16
366.12	7.261	0.7993	0.7977	-0.20
422.01	128.372	0.7619	0.7594	-0.33
422.01	103.640	0.7581	0.7554	-0.35
422.01	69.378	0.7526	0.7496	-0.40
422.01	42.418	0.7480	0.7447	-0.45
422.01	7.398	0.7416	0.7377	-0.53
478.13	137.267	0.7084	0.7054	-0.42
478.13	103.295	0.7006	0.6974	-0.46
478.13	69.171	0.6918	0.6883	-0.51
478.13	41.867	0.6839	0.6801	-0.56
478.13	9.053	0.6730	0.6686	-0.66
534.35	137.267	0.6467	0.6441	-0.40
534.35	103.088	0.6334	0.6308	-0.41
534.35	69.040	0.6173	0.6144	-0.48
534.35	41.798	0.6007	0.5970	-0.61
534.35	19.954	0.5834	0.5770	-1.10
590.28	137.612	0.5752	0.5731	-0.36
590.28	103.433	0.5505	0.5485	-0.36
590.28	69.171	0.5110	0.5098	-0.23
590.28	51.637	0.4714	0.4736	0.46
590.28	43.170	0.4241	0.4364	2.85

RMS ERROR = 0.41 (excluding two points)

Table 5, Comparison of Calculated and Measured Toluene Density Data in the Vapor and Superheat Regions

Temperature K	Pressure Bar	Density, g/cc Meas	Density, g/cc Calc	Error %
588.38	5.123	0.0101	0.0101	0.49
588.38	9.501	0.0195	0.0196	0.61
588.38	13.370	0.0289	0.0289	0.01
588.38	16.852	0.0380	0.0380	-0.01
588.38	20.092	0.0472	0.0475	0.62
588.38	22.919	0.0562	0.0566	0.67
644.23	5.468	0.0097	0.0097	0.37
644.23	14.611	0.0276	0.0279	0.86
644.23	20.540	0.0408	0.0412	0.98
644.23	31.669	0.0700	0.0707	0.95
644.23	40.695	0.1004	0.1013	0.84
644.23	53.602	0.1645	0.1651	0.36
644.23	63.676	0.2434	0.2441	0.30
644.23	68.661	0.2868	0.2895	0.95
644.23	78.728	0.3552	0.3610	1.62
644.23	103.019	0.4339	0.4384	1.02
644.23	139.253	0.4877	0.4916	0.80
672.06	6.537	0.0112	0.0112	0.12
672.06	15.093	0.0273	0.0272	-0.24
672.06	21.368	0.0406	0.0402	-0.95
672.06	33.186	0.0685	0.0683	-0.37
672.06	42.212	0.0944	0.0940	-0.34
672.06	57.243	0.1501	0.1490	-0.74
672.06	69.040	0.2084	0.2066	-0.90
672.06	82.127	0.2815	0.2817	0.09
672.06	99.041	0.3547	0.3586	1.10
672.06	134.461	0.4354	0.4372	0.41
672.06	138.777	0.4424	0.4436	0.27

RMS ERROR = 0.66 (Excluding one point)

Table 6, Comparison of Calculated and Measured Liquid Density Data of Partially Degraded Toluene

Temp. K	Pressure Bar	Density, g/cc Meas	Density, g/cc Calc	Error % Degraded	Error % Pure[a)]	Error % Diff.
301.27	0.807	0.8581	0.8612	0.36		
338.30	136.447	0.8374	0.8385	0.13	0.16	-0.03
338.30	103.978	0.8346	0.8355	0.11	0.14	-0.03
338.30	70.206	0.8316	0.8323	0.09	0.14	-0.05
338.30	41.453	0.8290	0.8295	0.06	0.10	-0.04
338.30	7.398	0.8257	0.5260	0.03	0.07	-0.04
366.23	129.765	0.8132	0.8124	-0.10	-0.05	-0.05
366.23	102.530	0.8103	0.8094	-0.12	-0.08	-0.04
366.23	69.378	0.8064	0.8056	-0.10	-0.11	0.01
366.23	41.936	0.8036	0.8023	-0.17	-0.16	-0.01
366.23	7.054	0.7995	0.7978	-0.21	-0.20	-0.01
422.04	137.336	0.7636	0.7610	-0.34	-0.33	-0.01
422.04	104.536	0.7586	0.7558	-0.37	-0.33	-0.02
422.04	69.309	0.7530	0.7498	-0.42	-0.40	-0.02
422.04	41.660	0.7482	0.7448	-0.46	-0.45	-0.01
422.04	3.055	0.7395	0.7371	-0.33	-0.53	0.20
478.21	137.405	0.7082	0.7057	-0.36	-0.42	0.06
478.21	104.185	0.7005	0.6978	-0.38	-0.46	0.08
478.21	70.068	0.6904	0.6888	-0.24	-0.51	0.27
478.21	41.522	0.6834	0.6802	-0.47	-0.56	0.09
478.21	10.294	0.6734	0.6693	-0.61	-0.66	0.03
534.43	137.267	0.6469	0.6444	-0.39	-0.40	0.01
534.43	103.426	0.6339	0.6312	-0.42	-0.41	-0.01
534.43	69.178	0.6177	0.6147	-0.48	-0.48	0.00
534.43	41.522	0.6011	0.5971	-0.66	-0.61	-0.05
534.43	20.092	0.5838	0.5775	-1.08	-1.10	0.02
590.42	137.681	0.5762	0.5734	-0.49	-0.36	-0.13
590.42	103.088	0.5515	0.5484	-0.56	-0.36	-0.20
590.42	68.827	0.5122	0.5095	-0.53	-0.23	-0.30
590.42	51.568	0.4734	0.4738	0.08	0.46	-0.36
590.42	43.032	0.4286	0.4364	1.80	2.85	-1.05

RMS ERROR = 0.41

a) Table 4

Table 7, Comparison of Calculated and Measured Partially Degraded Toluene Density Data in the Vapor and Superheat Regions

Temperature K	Pressure Bar	Density, g/cc Meas	Density, g/cc Calc	Error % Degraded	Error % Pure[a)]
588.41	4.606	0.0090	0.0091	0.30	0.49
588.41	8.019	0.0163	0.0163	-0.13	0.61
588.41	11.473	0.0242	0.0243	0.09	-
588.41	14.749	0.0324	0.0324	0.16	0.01
588.41	170.782	0.0406	0.0407	0.29	-0.01
588.41	20.540	0.0487	0.0489	0.44	0.62
588.41	22.988	0.0568	0.0570	0.35	0.67
644.23	7.054	0.0126	0.0127	1.09	0.37
644.23	13.818	0.0262	0.262	-0.18	0.86
644.23	20.885	0.0420	0.0420	-0.13	0.98
644.23	31.255	0.0694	0.0695	0.19	0.95
644.23	42.074	0.1071	0.1069	-0.15	0.84
644.23	54.113	0.1693	0.1689	-0.23	0.36
644.23	62.194	0.2317	0.2320	0.14	0.30
644.23	69.102	0.2927	0.2946	0.65	0.95
644.23	78.997	0.3589	0.3635	1.27	1.62
644.23	98.255	0.4264	0.4287	0.55	1.02
644.23	116.527	0.4611	0.4629	0.39	-
644.23	137.681	0.4891	0.4904	0.27	0.80
672.06	6.571	0.0113	0.0112	-0.05	0.12
672.06	15.197	0.0276	0.0274	-0.50	-0.24
672.06	21.402	0.0403	0.0403	-0.09	-0.95
672.06	32.428	0.0663	0.0664	0.03	-0.37
672.06	41.419	0.0916	0.0916	0.01	-0.34
672.06	56.959	0.1472	0.1465	-0.51	-0.74
672.06	68.489	0.2062	0.2042	-0.99	-0.90
672.06	83.017	0.2873	0.2874	0.05	0.09
672.06	101.068	0.3624	0.3661	1.02	1.10
672.06	139.155	0.4434	0.4447	0.27	0.27

RMS ERROR = 0.49

a) Table 5

Table 8, Comparison of Calculated and Measured Isobaric Enthalpy Differences of Pure Toluene of this Project at 0.885 Bar

Temperature, K		ΔH, KJ/mole		
Inlet	Outlet	Calc.	Meas.	Dev., KJ/mole
676.5	317.7	96.5	98.4	-1.9
676.9	317.9	96.6	98.0	-1.4
674.8	318.1	96.1	95.8	0.3
676.8	318.2	96.5	96.8	-0.3
588.4	317.2	78.9	89.3	-0.4
588.7	317.4	78.9	79.5	-0.6
588.8	317.4	78.9	79.6	-0.7
535.3	317.0	69.0	68.3	0.7
535.5	317.0	69.1	68.9	0.2
535.6	317.0	69.1	68.8	0.3
476.8	316.8	59.1	58.2	0.9
478.5	316.8	59.3	58.9	0.4
478.7	316.8	59.4	58.9	0.5
423.6	316.7	50.8	50.8	0.0
423.7	316.7	50.8	51.1	-0.3
423.7	316.7	50.8	50.9	-0.1
394.0	316.6	46.5	46.2	0.3
397.2	316.7	47.0	46.5	0.5

RMS Dev. 0.6 KJ/mole
(excluding -1.9 & -1.4)

Table 9, Comparison of Calculated and Measured Isobaric Enthalpy Differences of Pure Toluene of this Project at 41.5 bars

Temperature, K		ΔH, KJ/mole		
Inlet	Outlet	Calc.	Meas.	Dev., KJ/mole
676.8	318.4	90.8	90.2	0.6
678.0	318.5	91.0	90.8	0.2
678.1	318.8	91.0	90.2	0.8
583.4	317.7	56.5	55.2	1.3
583.6	317.7	56.5	55.2	1.3
583.2	317.8	56.4	54.7	0.7
536.0	317.3	43.5	43.2	0.3
535.9	317.4	43.5	42.9	0.6
535.8	317.4	43.5	42.7	0.8
477.8	317.0	30.4	28.5	1.9
477.8	317.1	30.4	30.0	0.4
477.7	317.0	30.4	30.4	0.0
423.7	316.5	19.4	18.2	1.2
423.4	316.7	19.3	18.6	0.7
			RMS Dev.	0.8 KJ/mole (excluding 1.9)

Table 10, Comparison of Calculated and Measured Isobaric Enthalpy Differences of Degraded Toluene of this Project at 0.886 bars

Temperature, K		ΔH, KJ/mole		
Inlet	Outlet	Calc.	Meas.	Dev., KJ/mole
759.1	113.0	96.64	96.20	0.40
759.2	112.7	96.68	97.04	-0.36
759.7	112.7	96.74	96.83	-0.09
600.5	111.5	78.99	79.00	-0.01
600.7	111.6	79.01	79.08	-0.07
499.2	111.3	68.59	68.43	0.16
501.6	111.2	68.84	68.47	0.37
402.7	110.8	59.46	59.21	0.25
403.0	110.9	59.48	59.65	-0.17
311.2	110.6	51.50	53.32	-1.82
316.1	110.7	51.89	53.53	-1.04
262.6	110.4	47.58	48.77	-1.19
262.9	110.4	47.60	48.85	-1.25

RMS Error 0.86 KJ/mole

Table 11, Comparison of Calculated and Measured Isobaric Enthalpy Differences of Degraded Toluene of this Project at 41.5 bars

Temperature, K		ΔH, KJ/mole		
Inlet	Outlet	Calc.	Meas.	Dev., KJ/mole
758.4	112.8	90.87	90.51	0.36
760.7	113.1	91.14	90.53	0.61
761.0	113.4	91.14	91.00	0.14
584.1	111.9	55.27	53.93	1.34
584.2	111.8	55.30	53.74	1.56
584.7	112.0	55.36	53.68	1.68
497.9	111.3	42.59	41.74	0.85
497.8	111.5	42.56	41.42	1.14
497.4	111.6	42.50	41.99	0.51
401.9	110.9	30.62	30.12	0.50
403.0	110.9	30.75	30.44	0.31
404.0	111.0	30.86	30.77	0.09
306.7	110.4	19.80	19.02	0.78
309.7	110.5	20.12	20.03	0.09

RMS error 0.88 KJ/mole

Table 12, Isothermal Enthalpy Measurements on Toluene and Partially Degraded Toluene

Sample	Temp. K	Pressure, Bars In	Pressure, Bars Out	ΔH, KJ/mole Meas.	ΔH, KJ/mole Calc.	Difference KJ/mole
Toluene	338.7	6.90	0.862	-0.036	-0.040	0.004
		41.4	1.021	-0.267	-0.266	-0.001
		48.3	1.000	-0.300	-0.312	0.012
		48.3	1.034	-0.299	-0.312	0.013
Toluene	672.0	6.90	0.979	0.52	0.55	-0.03
		6.90	0.972	0.52	0.55	-0.03
		41.4	1.103	5.12	5.43	0.31
		48.3	1.103	6.21	6.69	0.48
					RMS error	0.20
Degraded	338.7	6.90	0.883	-0.037	-0.039	0.002
		41.4	0.966	-0.271	-0.262	-0.009
		48.3	0.966	-0.307	-0.312	0.005
Degraded	672.0	6.90	0.979	0.57	0.55	0.02
		6.90	0.972	0.56	0.55	0.01
		41.4	1.103	5.10	5.43	-0.33
		48.3	1.103	6.30	6.69	-0.39
					RMS Error	0.19

Table 13, Principal Literature References on the Properties of Toluene.

Date	Reference	Type of Data
1930	Krase and Goodman; See J. Timmermans, Physico Chemical Constants of Pure Organic Compounds, Elsevier (1950)	vapor pressure 80 to 104°C
1930	Zmaczynski; See J. Timmermans, op cit	vapor pressure 111 to 161°C
1943	Griswold, Andres, and Klein; See J. Timmermans, Physico Chemical of Pure Organic Compounds, Vol. 2, Elsevier (1965)	vapor pressure 138 to 295°C
1945	Willingham, Taylor, Pignoco, and Rossini, See J. Timmermans (1950), op cit	vapor pressure 35 to 112°C
1949	Forziati, Norris and Rossini; See J. Timmermans (1965), op cit	vapor pressure 36 to 112°C
1954-55	Dreyer, Martin, and Von Weber; See J. Timmermans (1965), op cit	vapor pressure 40 to 110°C
1962	D. W. Scott, et al, J. Phys. Chem 66, 911-914 (1962)	Heat Capacity of liquid and ideal gas, and DH vaporization
1967	D. Ambrose, B. E. Broderick, and R. Townsend, J. Chem. Soc. London, Sec. A, 633-641(1967)	vapor pressure 420 to 580 K
1967	H. D. Rudolph et al, Zeitschrift fur Naturforschung 22a, 940-944 (1967)	IR Spectrum
1970	T. S. Akhundov and F. G. Abdullaev, Izv. Vyssh. Ucheb. Zaved, Neft Gaz 13, 67-69 (1970) (Most complete set of data from a single reference, also found to be precise and consistent with other data.)	vapor pressure Density & PVT 25 to 400°C and 0 to 500 bars

Table 13 (cont.)

Date	Reference	Type of Data
1972	J. L. Hales and R. Townsend, J. Chem. Thermodynamics 4, 763-772 (1972)	Liquid densities 293 to 490 K
1972	R. Kandiyoti and J. M. L. Penninger, Metu Journal of Pure and Applied Sciences 5, 157-163 (1972)	Liquid density 15°C to 500 atm.
1976	J. L. San Jose', G. Mellinger, and R. C. Reid, J. Chem. Eng. Data 21, 414-417 (1976)	Liquid heat capacity 120 to 230°C and 10 to 25 bars
1984	P. T. Eubank et al, J. Chem. Eng. Data 29, 389-393 (1984)	Liquid & vapor enthalpies 333 to 513 K and 1.2 to 94.1 bars
1985	G. Natarajan and D. S. Viswanath, J. Chem. Eng. Data 30, 137-140 (1985)	Heats of vaporization 380 to 521 K
1986	TRC Thermodynamic Tables, Texas A & M University (1986) Their tables were compared but not correlated.	Correlated data on vapor pressure, density, PVT, enthalpy, and ideal gas heat capacity

Table 14. Comparison of Calculated and Literature Density Data on Toluene
by T. S. Akhundov and F. G. Abdullaev, Izv. Vyssh Ucheb. Zaved., Neft Gaz 13, 67(1970)
(Principal Basis of Model)

Temperature K	Pressure Bar	Density, g/cc Meas	Calc	Error %
298.15	496.493	0.8963	0.8960	-0.04
298.15	398.726	0.8906	0.8906	-0.01
298.15	298.440	0.8843	0.8846	0.03
298.15	208.753	0.8784	0.8789	0.06
298.15	106.116	0.8712	0.8719	0.08
298.15	59.876	0.8678	0.8685	0.09
298 15	8.700	0.8638	0.8646	0.09
323.15	497.483	0.8770	0.8771	0.01
323.15	399.866	0.8707	0.8710	0.04
323.15	300.649	0.8637	0.8643	0.07
323.15	202.673	0.8565	0.8571	0.08
323.15	105.316	0.8485	0.8493	0.09
323.15	54.689	0.8442	0.8449	0.09
323.15	17.396	0.8408	0.8415	0.08
348.15	501.382	0.8585	0.8585	0.00
348.15	404.306	0.8515	0.8517	0.02
348.15	304.079	0.8437	0.8440	0.04
348.15	204.093	0.8352	0.8356	0.04
348.15	103.626	0.8259	0.8261	0.03
348.15	51.902	0.8207	0.8208	0.02
348.15	21.140	0.8175	0.8175	0.00
373.15	481.833	0.8386	0.8382	-0.05
373.15	403.986	0.8323	0.8320	-0.04
373.15	304.989	0.8237	0.8234	-0.03
373.15	208.443	0.8144	0.8141	-0.03
373.15	104.736	0.8033	0.8028	-0.05
373.15	51.736	0.7970	0.7964	-0.08
373.15	22.106	0.7933	0.7925	-0.11
398.15	431.105	0.8153	0.8149	-0.05
398.15	404.846	0.8129	0.8125	-0.06
398.15	305.829	0.8033	0.8028	-0.06
398.15	302.489	0.7920	0.8025	1.31
398.15	103.986	0.7797	0.7788	-0.11
398.15	51.500	0.7723	0.7712	-0.15
398.15	20.967	0.7677	0.7664	-0.18
423.15	504.342	0.8026	0.8028	0.02
423.15	406.306	0.7929	0.7932	0.03
423.15	302.609	0.7816	0.7817	0.02
423.15	204.663	0.7693	0.7694	0.01
423.15	105.736	0.7549	0.7546	-0.03
423.15	50.584	0.7456	0.7450	-0.08
423.15	17.202	0.7394	0.7385	-0.12
448.15	501.812	0.7841	0.7841	0.01
448.15	476.833	0.7815	0.7816	0.01
448.15	451.964	0.7788	0.7789	0.00
448.15	426.135	0.7760	0.7760	0.00
448.15	393.916	0.7728	0.7723	-0.06
448.15	377.207	0.7703	0.7703	0.01
448.15	353.298	0.7674	0.7674	0.01
448.15	328.258	0.7642	0.7643	0.01
448.15	300.259	0.7606	0.7606	0.00
448.15	275.390	0.7572	0.7572	0.00
448.15	251.831	0.7540	0.7539	-0.01
448.15	226.422	0.7503	0.7501	-0.02
448.15	201.213	0.7464	0.7462	-0.03
448.15	176.284	0.7424	0.7422	-0.03
448.15	150.325	0.7382	0.7378	-0.06
448.15	125.986	0.7338	0.7333	-0.07
448.15	101.466	0.7292	0.7286	-0.08
448.15	69.948	0.7229	0.7221	-0.12
448.15	51.448	0.7189	0.7179	-0.14
448.15	27.143	0.7131	0.7121	-0.14
448.15	10.492	0.7092	0.7078	-0.20
448.15	7.395	0.7085	0.7069	-0.22
473.15	501.402	0.7653	0.7659	0.08
473.15	476.513	0.7624	0.7630	0.08
473.15	452.194	0.7596	0.7601	0.07
473.15	423.675	0.7561	0.7566	0.06
473.15	403.096	0.7533	0.7540	0.10
473.15	375.967	0.7500	0.7505	0.06
473.15	350.568	0.7466	0.7470	0.05
473.15	325.619	0.7431	0.7434	0.05
473.15	299.419	0.7392	0.7396	0.05
473.15	275.520	0.7356	0.7359	0.04
473.15	251.331	0.7317	0.7320	0.04
473.15	226.932	0.7276	0.7278	0.03
473.15	201.613	0.7230	0.7233	0.04
473.15	175.764	0.7183	0.7184	0.01
473.15	153.375	0.7139	0.7139	0.00
473.15	126.916	0.7083	0.7082	-0.02
473.15	100.806	0.7024	0.7021	-0.04
473.15	75.229	0.6961	0.6957	-0.06
473.15	50.248	0.6893	0.6887	-0.08
473.15	26.173	0.6822	0.6813	-0.13
473.15	12.649	0.6778	0.6767	-0.17
473.15	9.138	0.6766	0.6754	-0.17
498.15	501.552	0.7473	0.7478	0.07
498.15	476.923	0.7442	0.7447	0.06
498.15	452.804	0.7411	0.7415	0.06
498.15	426.465	0.7375	0.7380	0.06
498.15	400.596	0.7339	0.7343	0.06
498.15	374.917	0.7301	0.7305	0.05
498.15	347.328	0.7260	0.7263	0.04
498.15	326.059	0.7225	0.7229	0.05
498.15	300.929	0.7183	0.7187	0.05
498.15	265.661	0.7121	0.7124	0.04

Table 14. Continued

Temperature K	Pressure Bar	Density, g/cc Meas	Calc	Error %
498.15	225.292	0.7043	0.7046	0.04
498.15	197.353	0.6985	0.6987	0.03
498.15	175.594	0.6937	0.6939	0.03
498.15	151.715	0.6880	0.6882	0.02
498.15	125.456	0.6813	0.6813	0.00
498.15	91.177	0.6715	0.6713	-0.03
498.15	75.727	0.6665	0.6662	-0.04
498.15	51.565	0.6580	0.6575	-0.08
498.15	25.927	0.6476	0.6465	-0.17
498.15	14.957	0.6426	0.6408	-0.28
498.15	11.942	0.6394	0.6389	-0.08
498.15	7.531	0.0193	0.0192	-0.31
523.15	500.672	0.7292	0.7296	0.06
523.15	473.393	0.7254	0.7258	0.06
523.15	459.804	0.7234	0.7239	0.07
523.15	426.515	0.7184	0.7189	0.07
523.15	402.466	0.7146	0.7151	0.07
523.15	376.137	0.7103	0.7108	0.07
523.15	352.248	0.7063	0.7068	0.07
523.15	326.949	0.7017	0.7022	0.07
523.15	301.739	0.6970	0.6974	0.06
523.15	277.120	0.6920	0.6925	0.07
523.15	251.841	0.6867	0.6871	0.06
523.15	226.382	0.6809	0.6813	0.06
523.15	201.243	0.6748	0.6752	0.06
523.15	175.184	0.6679	0.6683	0.05
523.15	150.785	0.6609	0.6612	0.05
523.15	124.736	0.6526	0.6528	0.04
523.15	102.446	0.6447	0.6448	0.02
523.15	75.247	0.6336	0.6335	-0.02
523.15	50.084	0.6214	0.6209	-0.09
523.15	25.801	0.6068	0.6051	-0.28
523.15	19.340	0.6022	0.5997	-0.42
523.15	17.177	0.6002	0.5977	-0.42
523.15	15.086	0.0425	0.0422	-0.61
523.15	12.085	0.0314	0.0314	-0.21
523.15	8.277	0.0199	0.0199	-0.04
523.15	4.582	0.0104	0.0104	-0.10
523.15	2.742	0.0060	0.0060	-0.10
548.15	477.243	0.7074	0.7081	0.09
548.15	451.244	0.7033	0.7039	0.09
548.15	426.405	0.6992	0.6998	0.09
548.15	401.306	0.6947	0.6954	0.10
548.15	375.747	0.6901	0.6907	0.09
548.15	351.968	0.6855	0.6862	0.10
548.15	327.239	0.6805	0.6812	0.10
548.15	301.619	0.6750	0.6757	0.10
548.15	276.820	0.6706	0.6700	-0.09
548.15	251.091	0.6630	0.6637	0.11
548.15	227.842	0.6568	0.6575	0.11
548.15	201.293	0.6491	0.6499	0.11
548.15	175.954	0.6411	0.6419	0.12
548.15	150.195	0.6320	0.6327	0.11
548.15	125.966	0.6224	0.6230	0.11
548.15	76.067	0.5970	0.5974	0.06
548.15	50.917	0.5791	0.5791	-0.01
548.15	30.789	0.5593	0.5585	-0.15
548.15	25.742	0.5528	0.5517	-0.21
548.15	24.751	0.5515	0.5502	-0.22
548.15	14.133	0.0350	0.0349	-0.31
548.15	8.501	0.0192	0.0191	-0.11
548.15	3.968	0.0084	0.0084	-0.01
573.15	501.692	0.6933	0.6938	0.07
573.15	572.640	0.6884	0.7048	2.35
573.15	450.834	0.6846	0.6851	0.07
573.15	425.665	0.6799	0.6804	0.07
573.15	403.126	0.6755	0.6761	0.08
573.15	374.317	0.6697	0.6703	0.09
573.15	349.488	0.6642	0.6649	0.10
573.15	326.599	0.6590	0.6596	0.09
573.15	300.209	0.6524	0.6532	0.11
573.15	275.050	0.6458	0.6465	0.12
573.15	251.701	0.6391	0.6399	0.12
573.15	226.132	0.6312	0.6320	0.14
573.15	200.673	0.6224	0.6233	0.14
573.15	176.724	0.6132	0.6141	0.15
573.15	151.155	0.6020	0.6029	0.15
573.15	124.926	0.5887	0.5895	0.15
573.15	100.646	0.5735	0.5744	0.15
573.15	75.457	0.5531	0.5540	0.16
573.15	50.711	0.5231	0.5244	0.25
573.15	37.405	0.4948	0.4983	0.70
573.15	33.065	0.4793	0.4852	1.22
573.15	27.538	0.0822	0.0818	-0.51
573.15	22.430	0.0589	0.0588	-0.14
573.15	17.069	0.0407	0.0406	-0.09
573.15	8.374	0.0177	0.0177	-0.04
573.15	3.806	0.0076	0.0076	-0.05
598.15	502.382	0.6752	0.6759	0.10
598.15	474.403	0.6701	0.6708	0.10
598.15	447.844	0.6648	0.6656	0.12
598.15	425.945	0.6582	0.6612	0.45
598.15	400.786	0.6550	0.6558	0.12
598.15	376.907	0.6495	0.6504	0.14
598.15	350.178	0.6430	0.6440	0.15
598.15	326.429	0.6368	0.6378	0.16
598.15	300.729	0.6297	0.6307	0.16
598.15	277.030	0.6225	0.6236	0.17
598.15	251.101	0.6139	0.6151	0.19
598.15	225.402	0.6045	0.6057	0.20

Table 14. Continued

Temperature K	Pressure Bar	Density. g/cc Meas	Calc	Error %
598.15	201.073	0.5945	0.5958	0.20
598.15	173.734	0.5817	0.5830	0.22
598.15	151.675	0.5697	0.5708	0.19
598.15	125.576	0.5524	0.5535	0.20
598.15	102.056	0.5323	0.5334	0.21
598.15	75.967	0.4996	0.5011	0.30
598.15	56.163	0.4519	0.4567	1.07
598.15	50.384	0.4225	0.4306	1.90
598.15	48.395	0.4054	0.4148	2.29
598.15	46.791	0.3845	0.3934	2.28
598.15	45.714	0.3595	0.3632	1.01
598.15	45.223	0.3400	0.3401	0.03
598.15	44.871	0.3190	0.3186	-0.12
598.15	44.583	0.2946	0.2971	0.82
598.15	44.361	0.2730	0.2798	2.46
598.15	43.870	0.2352	0.2459	4.44
598.15	43.257	0.2066	0.2133	3.19
598.15	42.159	0.1774	0.1790	0.92
598.15	40.720	0.1551	0.1548	-0.21
598.15	39.199	0.1380	0.1377	-0.20
598.15	37.087	0.1203	0.1195	-0.68
598.15	34.237	0.1015	0.1014	-0.14
598.15	30.850	0.0843	0.0843	-0.05
598.15	27.309	0.0697	0.0697	-0.05
598.15	21.979	0.0515	0.0515	0.01
623.15	502.072	0.6575	0.6578	0.04
623.15	475.843	0.6523	0.6526	0.04
623.15	452.184	0.6472	0.6476	0.05
623.15	431.355	0.6403	0.6429	0.41
623.15	402.486	0.6358	0.6362	0.05
623.15	374.467	0.6288	0.6292	0.06
623.15	350.908	0.6224	0.6228	0.07
623.15	327.929	0.6157	0.6161	0.06
623.15	302.029	0.6076	0.6080	0.07
623.15	276.150	0.5987	0.5991	0.08
623.15	251.151	0.5891	0.5896	0.09
623.15	225.812	0.5783	0.5788	0.08
623.15	201.093	0.5663	0.5667	0.08
623.15	176.324	0.5522	0.5527	0.10
623.15	151.605	0.5352	0.5358	0.10
623.15	101.496	0.4826	0.4833	0.14
623.15	76.137	0.4267	0.4291	0.56
623.15	57.864	0.2947	0.2945	-0.08
623.15	55.641	0.2600	0.2599	-0.02
623.15	54.110	0.2361	0.2368	0.26
623.15	52.273	0.2103	0.2108	0.24
623.15	49.797	0.1818	0.1820	0.14
623.15	47.544	0.1610	0.1604	-0.34
623.15	42.712	0.1271	0.1267	-0.33
623.15	39.745	0.1110	0.1107	-0.22
623.15	35.864	0.0933	0.0931	-0.20
623.15	30.989	0.0748	0.0746	-0.20
623.15	25.981	0.0587	0.0587	0.04
623.15	21.034	0.0448	0.0449	0.05
623.15	16.203	0.0329	0.0329	0.05
623.15	11.327	0.0220	0.0220	0.06
623.15	5.267	0.0097	0.0097	0.02
648.15	498.383	0.6395	0.6389	-0.09
648.15	476.773	0.6348	0.6342	-0.09
648.15	452.584	0.6291	0.6286	-0.08
648.15	428.025	0.6231	0.6226	-0.07
648.15	402.006	0.6163	0.6159	-0.06
648.15	377.257	0.6093	0.6090	-0.05
648.15	353.448	0.6022	0.6019	-0.04
648.15	327.169	0.5937	0.5934	-0.05
648.15	301.349	0.5845	0.5843	-0.04
648.15	277.270	0.5750	0.5749	-0.03
648.15	250.911	0.5634	0.5633	-0.03
648.15	226.432	0.5513	0.5511	-0.03
648.15	202.383	0.5374	0.5373	-0.02
648.15	176.254	0.5194	0.5192	-0.03
648.15	152.165	0.4989	0.4985	-0.06
648.15	127.196	0.4703	0.4701	-0.03
648.15	109.116	0.4411	0.4415	0.08
648.15	100.986	0.4233	0.4247	0.33
648.15	87.847	0.3856	0.3872	0.41
648.15	76.397	0.3300	0.3313	0.41
648.15	66.008	0.2519	0.2499	-0.80
648.15	54.748	0.1673	0.1657	-0.98
648.15	45.114	0.1175	0.1168	-0.61
648.15	35.397	0.0813	0.0810	-0.35
648.15	25.519	0.0529	0.0528	-0.18
648.15	15.668	0.0299	0.0298	-0.06
673.15	391.426	0.5930	0.5924	-0.11
673.15	346.468	0.5784	0.5777	-0.12
673.15	305.709	0.5629	0.5622	-0.12
673.15	276.160	0.5499	0.5492	-0.13
673.15	250.501	0.5371	0.5363	-0.16
673.15	226.062	0.5231	0.5222	-0.18
673.15	198.753	0.5044	0.5034	-0.20
673.15	174.554	0.4840	0.4830	-0.20
673.15	151.325	0.4591	0.4583	-0.17
673.15	125.896	0.4210	0.4212	0.03
673.15	101.276	0.3612	0.3632	0.57
673.15	88.837	0.3196	0.3138	-1.83
673.15	75.727	0.2452	0.2419	-1.34
673.15	55.045	0.1383	0.1387	0.32
673.15	44.985	0.1030	0.1023	-0.64
673.15	30.270	0.0608	0.0606	-0.24
673.15	16.262	0.0295	0.0295	-0.11

RMS ERROR = 0.24, excluding errors > 11.3%

Table 15, Comparison of Calculated and Literature Liquid Density of Toluene Data of Hales and Townsend (1972)

Temperature K	Pressure Bar	Density, g/cc Meas	Density, g/cc Calc	Error %
293.15	0.029	0.8668	0.8686	0.21
298.15	0.038	0.8622	0.8639	0.20
303.15	0.049	0.8575	0.8592	0.19
320.00	0.107	0.8417	0.8429	0.15
340.00	0.242	0.8226	0.8233	0.08
360.00	0.491	0.8030	0.8031	0.01
370.00	0.676	0.7931	0.7928	-0.03
390.00	1.208	0.7727	0.7718	-0.11
410.00	2.024	0.7514	0.7501	-0.17
430.00	3.210	0.7292	0.7276	-0.22
450.00	4.860	0.7056	0.7040	-0.23
470.00	7.080	0.6804	0.6789	-0.22
480.00	8.440	0.6670	0.6657	-0.19

RMS ERROR = 0.18

Table 16, Comparison of Calculated Liquid Densities of Toluene with TRC Density Tables[a)]

Temperature K	Pressure Bar	Density, g/cc TRC	Density, g/cc Calc	Error %
273.15	0.009	0.8845	0.8872	0.31
283.15	0.017	0.8757	0.8780	0.26
293.15	0.029	0.8669	0.8686	0.20
303.15	0.049	0.8576	0.8592	0.18
313.15	0.079	0.8482	0.8496	0.16
323.15	0.123	0.8388	0.8399	0.13
333.15	0.185	0.8292	0.8300	0.10
343.15	0.272	0.8196	0.8201	0.06
353.15	0.389	0.8098	0.8101	0.03
363.15	0.544	0.7999	0.7999	0.00
373.15	0.744	0.7899	0.7896	-0.04
383.15	0.998	0.7797	0.7791	-0.08
393.15	1.315	0.7693	0.7685	-0.11
403.15	1.707	0.7588	0.7577	-0.15
413.15	2.183	0.7480	0.7467	-0.18
423.15	2.754	0.7369	0.7354	-0.20
433.15	3.433	0.7256	0.7239	-0.23
443.15	4.233	0.7139	0.7122	-0.24
453.15	5.166	0.7018	0.7001	-0.24
463.15	6.245	0.6893	0.6877	-0.24
473.15	7.485	0.6763	0.6748	-0.22
483.15	8.900	0.6626	0.6613	-0.19
493.15	10.506	0.6484	0.6463	-0.33
503.15	12.320	0.6333	0.6307	-0.41
513.15	14.356	0.6173	0.6143	-0.48
523.15	16.637	0.6002	0.5971	-0.52
533.15	19.182	0.5817	0.5788	-0.50
543.15	22.014	0.5613	0.5589	-0.42
553.15	25.160	0.5384	0.5371	-0.24
563.15	28.656	0.5119	0.5125	0.11
573.15	32.543	0.4792	0.4832	0.82
583.15	32.543	0.4332	0.4431	2.27
589.80	32.543	0.3760	0.3664	-2.59

RMS ERROR = 0.29 (Excluding two points)

a) These data are for comparison only and were not correlated.

Table 17, Comparison of Calculated Vapor and Superheat Densities of Toluene with TRC PVT Tables[a)]

Temperature K	Pressure Bar	Density, g/cc TRC	Density, g/cc Calc	Error %
390.00	1.013	0.0030	0.0030	0.42
410.00	2.000	0.0057	0.0058	0.79
430.00	3.000	0.0083	0.0084	1.01
450.00	4.000	0.0108	0.0109	1.06
470.00	5.000	0.0130	0.0131	1.13
510.00	10.000	0.0256	0.0260	1.48
530.00	10.000	0.0240	0.0243	1.16
550.00	10.000	0.0224	0.0229	2.25
550.00	19.999	0.0549	0.0557	1.51
570.00	10.000	0.0216	0.0217	0.70
570.00	19.999	0.0501	0.0507	1.15
570.00	29.999	0.1002	0.1002	-0.02
591.80	10.000	0.0205	0.0206	0.57
591.80	19.999	0.0463	0.0466	0.64
591.80	29.999	0.0836	0.0837	0.09
591.80	39.999	0.1921	0.1724	-10.79
591.80	49.998	0.2926	0.4620	45.68
591.80	99.996	0.5350	0.5428	1.45
591.80	249.991	0.6242	0.6210	-0.51
610.00	10.000	0.0197	0.0198	0.31
610.00	19.999	0.0437	0.0439	0.53
610.00	29.999	0.0756	0.0757	0.11
610.00	39.999	0.1025	0.1251	19.96
610.00	49.998	0.1806	0.2722	41.04
610.00	99.996	0.4694	0.5085	8.00
610.00	249.991	0.6138	0.6027	-1.82
630.00	10.000	0.0189	0.0189	0.25
630.00	19.999	0.0413	0.0414	0.27
630.00	29.999	0.0693	0.0693	0.00
630.00	39.999	0.1086	0.1068	-1.61
630.00	49.998	0.1468	0.1662	12.39
630.00	99.996	0.4629	0.4656	0.59
630.00	249.991	0.5903	0.5820	-1.41
650.00	10.000	0.0182	0.0182	0.15
650.00	19.999	0.0392	0.0393	0.12
650.00	29.999	0.0646	0.0645	-0.18
650.00	39.999	0.0970	0.0958	-1.20
650.00	49.998	0.1288	0.1375	6.57
650.00	99.996	0.4168	0.4178	0.22
650.00	249.991	0.5706	0.5609	-1.71
670.00	10.000	0.0175	0.0175	0.05
670.00	19.999	0.0374	0.0374	-0.02
670.00	29.999	0.0607	0.0605	-0.37
670.00	39.999	0.0890	0.0879	-1.27
670.00	49.998	0.1134	0.1216	6.93
670.00	99.996	0.3684	0.3671	-0.36
670.00	249.991	0.5506	0.5394	-2.05

RMS ERROR = 0.65 (Excluding deviations > 11.3%)

a) These data are for comparison only and were not correlated.

Table 18. Comparison of Calculated and Literature Vapor Pressure Data of Toluene

Temperature K	Pressure, Bar Calc.	Meas.	Error %
352.92	0.38545	0.38603[a]	0.15
359.00	0.47345	0.47443	0.21
365.12	0.57851	0.57916	0.11
371.29	0.70099	0.70246	0.21
377.50	0.84517	0.84683	0.20
383.75	1.01330	1.01483	0.15
390.06	1.20809	1.20958	0.12
396.40	1.43275	1.43407	0.09
402.80	1.69074	1.69145	0.04
409.23	1.98553	1.98531	-0.01
415.71	2.32126	2.31942	-0.08
422.24	2.70164	2.69776	-0.14
428.81	3.12976	3.12427	-0.18
448.65	5.24889	4.72876[b]	-10.44
459.65	6.20140	5.84959	-5.84
467.15	7.07283	6.72050	-5.11
476.65	8.36986	7.95971	-5.02
487.55	10.02154	9.58226	-4.48
499.15	12.03800	11.56850	-3.98
507.65	13.42622	13.20724	-1.64
519.15	16.21280	15.69513	-3.25
523.15	17.27676	16.63747	-3.77
526.65	17.69275	17.49640	-1.12
530.35	17.83408	18.44235	3.35
537.15	21.67395	20.27857	-6.65
552.65	25.14050	24.99528	-0.58
553.15	25.43383	25.16041	-1.08
556.15	26.34580	26.16925	-0.67
574.65	32.83092	33.16582	1.01
411.15	2.37904	2.08005[c]	-13.43
462.15	6.17172	6.12989	-0.68
500.15	12.06760	11.75295	-2.64
526.15	17.58422	17.37169	-1.22
568.15	31.16889	30.54753	-2.01
308.65	0.06398	0.06373[d]	-0.39
312.59	0.07690	0.07668	-0.29
319.15	0.10329	0.10314	-0.15
322.04	0.11720	0.11702	-0.15
326.00	0.13841	0.13843	0.01
330.46	0.16633	0.16641	0.05
335.02	0.19943	0.19955	0.06
339.26	0.23474	0.23506	0.13
344.91	0.28978	0.29023	0.16
350.11	0.34926	0.34995	0.20
356.38	0.43361	0.43454	0.21
362.85	0.53700	0.53827	0.24
369.73	0.66798	0.66953	0.23
377.20	0.83752	0.83944	0.23
382.48	0.97649	0.97863	0.22
383.04	0.99237	0.99457	0.22
383.57	1.00729	1.00957	0.23
384.17	1.02466	1.02684	0.21
384.70	1.04003	1.04225	0.21
383.40	1.00050	1.00471[e]	0.42
372.16	0.72104	0.72148	0.06
363.41	0.54758	0.54820	0.11
352.60	0.38159	0.38175	0.04
342.73	0.26799	0.26784	-0.06
333.56	0.18799	0.18839	0.21
322.91	0.12200	0.12146	-0.44
312.88	0.07760	0.07773	0.17
308.52	0.06357	0.06332[f]	-0.40
312.49	0.07654	0.07635	-0.25
315.96	0.08962	0.08947	-0.17
319.10	0.10304	0.10291	-0.12
322.02	0.11700	0.11688	-0.10
325.95	0.13818	0.13816	-0.02
330.35	0.16622	0.16566	-0.34
335.00	0.19923	0.19941	0.09
339.23	0.23451	0.23481	0.12
344.89	0.28954	0.29002	0.17
350.09	0.34899	0.34967	0.19
356.35	0.43323	0.43412	0.21
362.82	0.53656	0.53778	0.23
369.71	0.66755	0.66909	0.23
377.19	0.83721	0.83907	0.22
382.46	0.97607	0.97818	0.22
383.03	0.99203	0.99415	0.21
383.55	1.00695	1.00909	0.21
384.14	1.02390	1.02606	0.21
384.66	1.03909	1.04119	0.20
423.15	2.75991	2.75410[g]	-0.21
448.15	4.69318	4.68198	-0.24
473.15	7.49975	7.48511	-0.20
498.15	11.42496	11.38620	-0.34
523.15	16.71012	16.63747	-0.44
548.15	23.69522	23.54503	-0.64
573.15	32.73359	32.54340	-0.58
440.00	3.96586	3.96756[h]	0.04
460.00	5.89379	5.88824	-0.09
480.00	8.45370	8.43465	-0.23
500.00	11.77059	11.72515	-0.39
520.00	15.97644	15.89192	-0.53
540.00	21.22126	21.08822	-0.63
560.00	27.67503	27.51420	-0.58
580.00	35.56675	35.46883	-0.28

RMS ERROR = 0.26, excluding References b) and c) which were not used.

a) Zmaczynski (1930)
b) Krase & Goodman (1930)
c) Griswold, Andres & Klein (1943)
d) Forziati, Norris & Rossini (1949)
e) Dreyer, Martin & Von Weber (1954-1955)
f) Willingham, Taylor, Pignoco & Rossini (1945)
g) Akhundov & Abdullaev (1970)
h) Ambrose, Broderick & Townsend (1967)

Table 19. Comparison of Calculated Vapor Pressures of Toluene with TRC Thermodynamic Tables[a)]

Temperature K	Pressure, Bar TRC	Pressure, Bar Meas.	Error %	Temperature K	Pressure, Bar TRC	Pressure, Bar Meas.	Error %
280.37	0.01407	0.01401	-0.38	347.04	0.31304	0.31359	0.18
283.15	0.01662	0.01652	-0.57	349.82	0.34558	0.34628	0.20
285.93	0.01951	0.01941	-0.54	352.59	0.38088	0.38168	0.21
288.71	0.02282	0.02272	-0.47	355.37	0.41894	0.41992	0.23
291.48	0.02661	0.02649	-0.47	358.15	0.46011	0.46119	0.23
294.26	0.03096	0.03079	-0.55	360.93	0.50437	0.50564	0.25
297.04	0.03585	0.03566	-0.53	363.71	0.55202	0.55345	0.26
299.82	0.04137	0.04118	-0.47	366.48	0.60325	0.60479	0.26
302.59	0.04758	0.04739	-0.38	369.26	0.65813	0.65985	0.26
305.37	0.05461	0.05438	-0.42	372.04	0.71695	0.71882	0.26
308.15	0.06240	0.06222	-0.30	374.82	0.77983	0.78188	0.26
310.93	0.07116	0.07098	-0.26	377.59	0.84706	0.84922	0.25
313.71	0.08095	0.08074	-0.25	380.37	0.91884	0.92106	0.24
316.48	0.09177	0.09160	-0.18	383.15	0.99523	0.99758	0.24
319.26	0.10384	0.10366	-0.18	385.93	1.07660	1.07901	0.22
322.04	0.11715	0.11699	-0.13	388.71	1.16306	1.16554	0.21
324.82	0.13183	0.13172	-0.09	391.48	1.25490	1.25753	0.21
327.59	0.14804	0.14794	-0.07	394.26	1.35233	1.35497	0.19
330.37	0.16583	0.16579	-0.02	397.04	1.45555	1.45818	0.18
333.15	0.18534	0.18535	0.01	399.82	1.56477	1.56739	0.17
335.93	0.20665	0.20677	0.06	402.59	1.68033	1.68283	0.15
338.71	0.22995	0.23016	0.09	405.37	1.80230	1.80474	0.13
341.48	0.25539	0.25567	0.11	408.15	1.93110	1.93335	0.12
344.26	0.28304	0.28343	0.14	410.93	2.06687	2.06890	0.10

RMS ERROR = 0.28

a) This table is for comparison only. These data were not correlated.

Table 20, Comparison of Calculated and Literature

Heats of Vaporization Data on Toluene

Temp. K	ΔH, KJ/mole Calc.	Lit.	Dev. %	Reference
341.27	35.77	35.65	0.34	Scott et al. (1962)
361.06	34.62	34.53	0.26	
383.77	33.25	33.19	0.18	
410.11	31.56	31.54	0.06	
379.63	33.51	33.47	0.12	Natarajan and
380.63	33.44	33.41	0.09	Viswanath (1985)
388.13	32.98	33.11	-0.39	
393.26	32.66	32.69	-0.09	
402.56	32.06	32.12	-0.19	
408.77	31.65	31.59	0.19	
417.50	31.44	31.06	1.22	
424.85	30.56	30.62	-0.20	
432.03	30.06	30.11	-0.17	
440.72	29.43	29.38	0.17	
445.27	29.09	29.15	-0.21	
458.30	28.08	28.10	-0.07	
470.39	27.10	27.07	0.11	
498.96	24.48	24.47	0.04	
504.50	23.92	24.02	-0.42	
251.13	22.08	22.15	-0.32	

RMS ERROR 0.22% (excluding 1.22%)

Table 21, Comparison of Calculated and Literature

Liquid Heat Capacity Data of Toluene

Temp. K	C(satn), J/mole-K Calc.	Lit.	Dev. %	Reference
280	151.6	152.3	-0.5	Scott et al. (1962)
290	155.6	155.0	0.4	
300	159.4	157.7	1.1	
310	163.0	160.7	1.4	
320	166.4	163.7	1.6	
330	169.7	166.8	1.7	
340	173.0	169.8	1.9	
350	176.1	172.8	1.9	
360	179.2	176.0	1.8	

Temp. K		Pressure, Bars 10	15	20	25	Reference
393.15	Calc.	188.8	188.7	188.5	188.4	San Jose'et al. (1976)
	Lit.	188.9	188.9	188.9	188.9	
	Dev., %	-0.1	-0.1	-0.2	-0.3	
413.15	Calc.	194.8	194.6	194.4	194.2	
	Lit.	195.3	195.3	195.3	195.3	
	Dev., %	-0.3	-0.4	-0.5	-0.6	
433.15	Calc.	201.0	200.8	200.6	200.3	
	Lit.	203.6	202.7	202.7	202.7	
	Dev., %	-1.3	-0.9	-1.0	-1.2	
453.15	Calc.	207.8	207.4	207.0	206.7	
	Lit.	212.8	211.9	211.9	211.0	
	Dev., %	-2.4	-2.1	-2.3	-2.1	
473.15	Calc.	215.2	214.7	214.1	213.7	
	Lit.	223.9	223.0	221.1	220.2	
	Dev., %	-4.0	-3.8	-3.2	-3.0	
483.15	Calc.		218.8	218.2	217.5	
	Lit.		228.5	226.7	225.7	
	Dev., %		-4.3	-3.8	-3.7	
493.15	Calc.		223.7	222.8	222.1	
	Lit.		235.9	233.1	231.3	
	Dev., %		-5.3	-4.5	-4.1	
503.15	Calc.		228.6	227.5	226.5	
	Lit.		243.2	239.6	236.8	
	Dev., %		-6.2	-5.2	-4.4	

Table 22. Comparison of Calculated and Literature Enthalpy Data on

Toluene of Eubank et al. (1984). KJ/mole referred to 298.15 K and 0.04 bar

		33.8 bars			63.1 bars			94.1 bars		
Temp. K	Region	Calc.	Lit.	Dev. KJ/mole	Calc.	Lit.	Dev. KJ/mole	Calc.	Lit.	Dev. KJ/mole
333.15	L	5.99	6.35	-0.36	6.19	6.37	-0.18	6.40	7.23	-0.83
353.15	L	9.46	9.63	-0.17	9.65	9.67	-0.02	9.86	10.55	-0.69
373.15	L	13.05	12.95	0.10	13.23	13.02	0.21	13.43	13.92	-0.49
393.15	L	16.75	16.36	0.39	16.92	16.45	0.47	17.11	17.37	-0.26
413.15	L	20.58	19.50	0.58	20.73	20.01	0.72	20 91	20.99	-0.08
433.15	L	24.46[a]	23.61[a]	0.85	24.64	23.76	0.88	24.81	24.81	0.00
453.15	L	28.53[a]	27.51[a]	1.02	28.68	27.77	0.91	28.82	28.88	-0.06
473.15	L	32.76[b]	31.91[b]	0.85	32.83	32.10	0.73	32.94	33.28	-0.34
493.15	L	37.10[b]	36.50[b]	0.60	37.11	36.84	0.27	37.18	37.95	-0.37
513.15	L	41.60[b]	41.49[b]	0.11	41.53	42.09	-0.56	41.55	43.40	-1.85

		1.2 bars			3.1 bars		
		Calc.	Lit.	Dev. KJ/mole	Calc.	Lit.	Dev. KJ/mole
393.15	V	49.28	48.78	0.50			
413.15	V	52.15	51.70	0.45			
433.15	V	55.13	54.64	0.49			
443.15					56.04	55.17	0.87
453.15	V	58.22	57.68	0.54	57.64	56.72	0.92
473.15	V	61.42	60.90	0.52	60.90	59.87	1.03
493.15	V	64.73	64.29	0.44	64.26	63.24	1.02
503.15	V				65.98	65.10	0.88

Overall RMS Dev. 0.6 KJ/mole
(excluding -1.85)

a) 21.5 bars

b) 32.1 bars

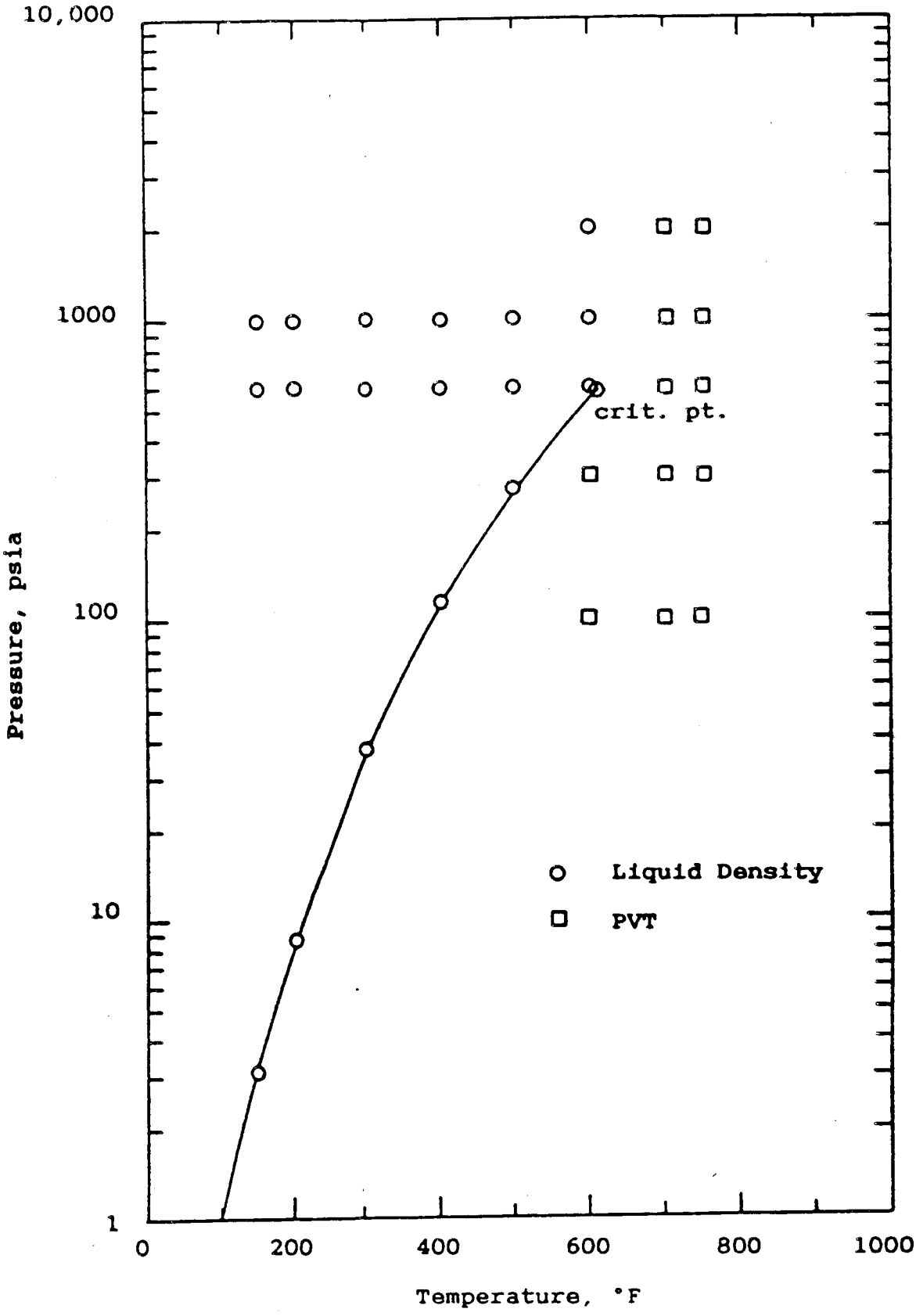

Figure 1. Planned Liquid Density and PVT Points on Toluene and Partially Degraded Toluene.

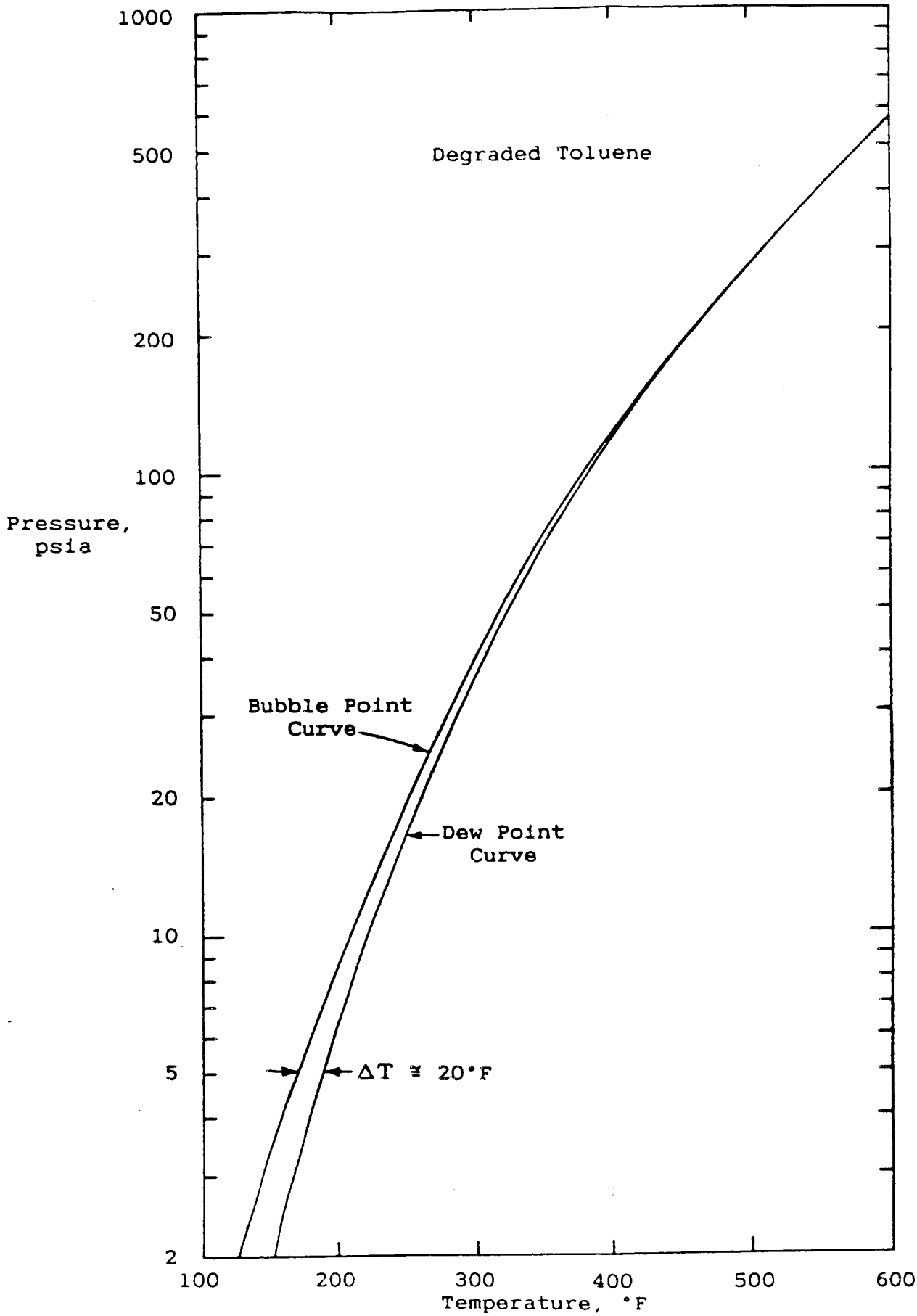

Figure 2. Vapor Pressure of Degraded Toluene.

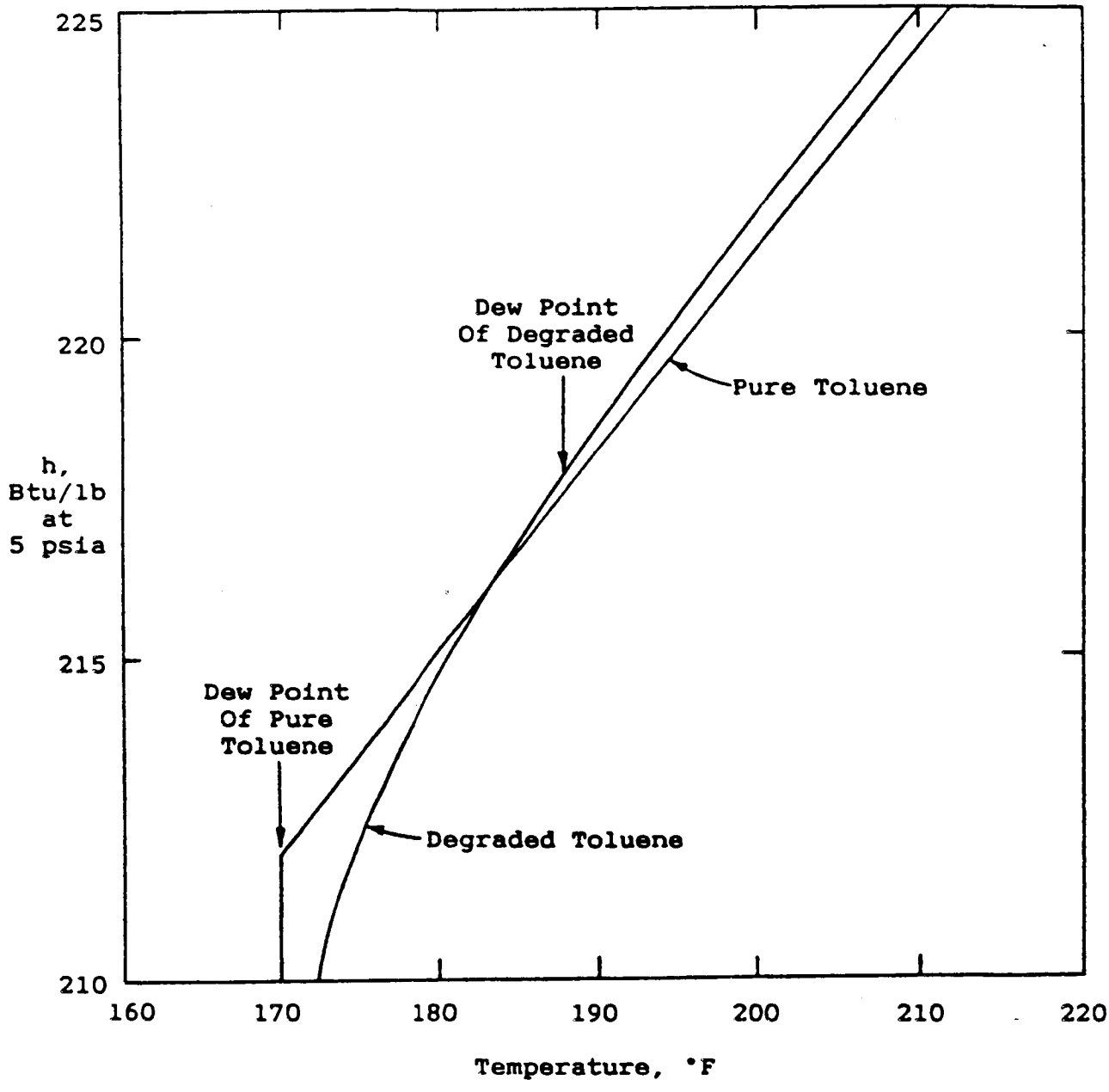

Figure 3. Dew Point Region; Comparison of Temperature-Enthalpy Plots of Degraded Toluene Versus Pure Toluene at 5 psia, h = 0 at 60°F and 14.5 psia. (The T-S plot has analogous features.)

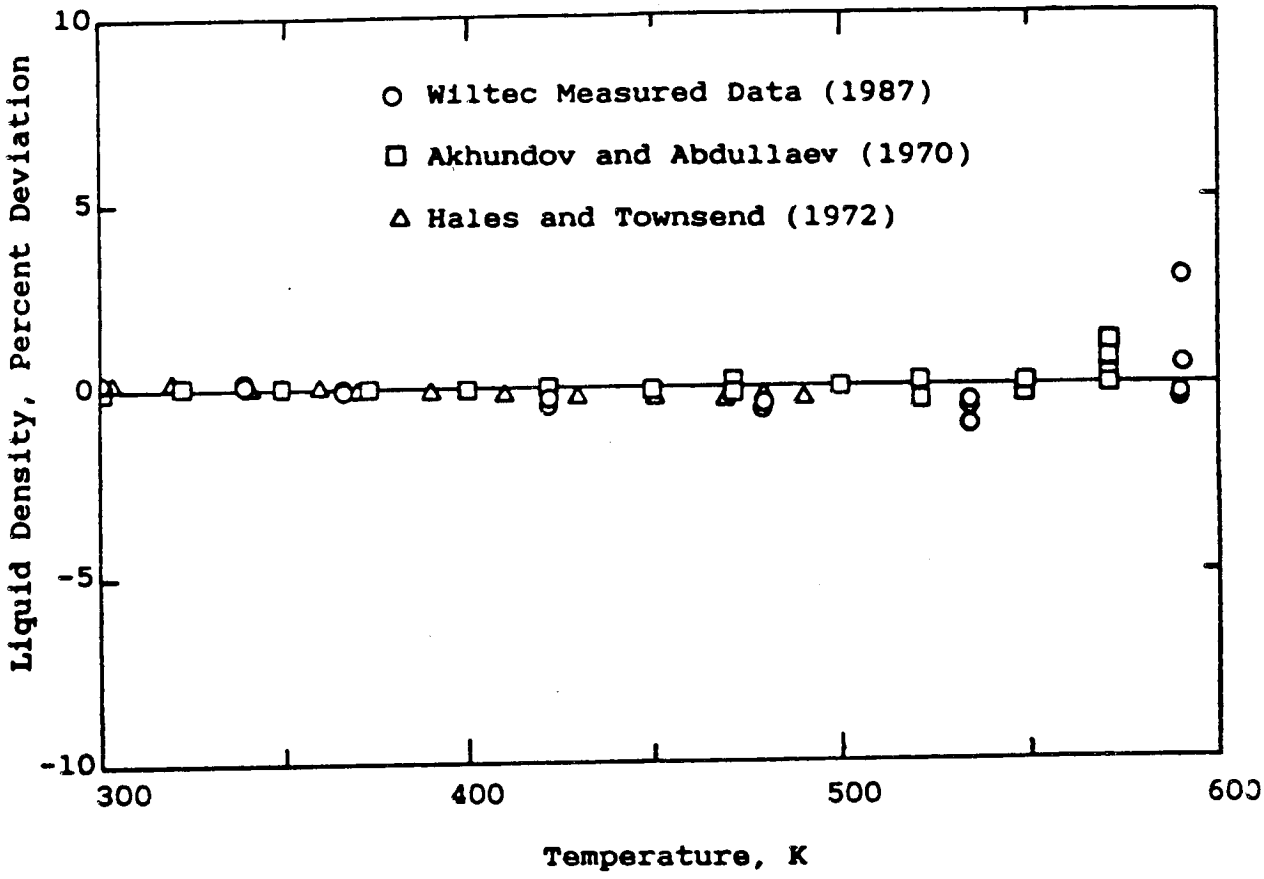

Figure 4. Deviations in Calculated and Measured or Literature Liquid Density Data of Toluene.

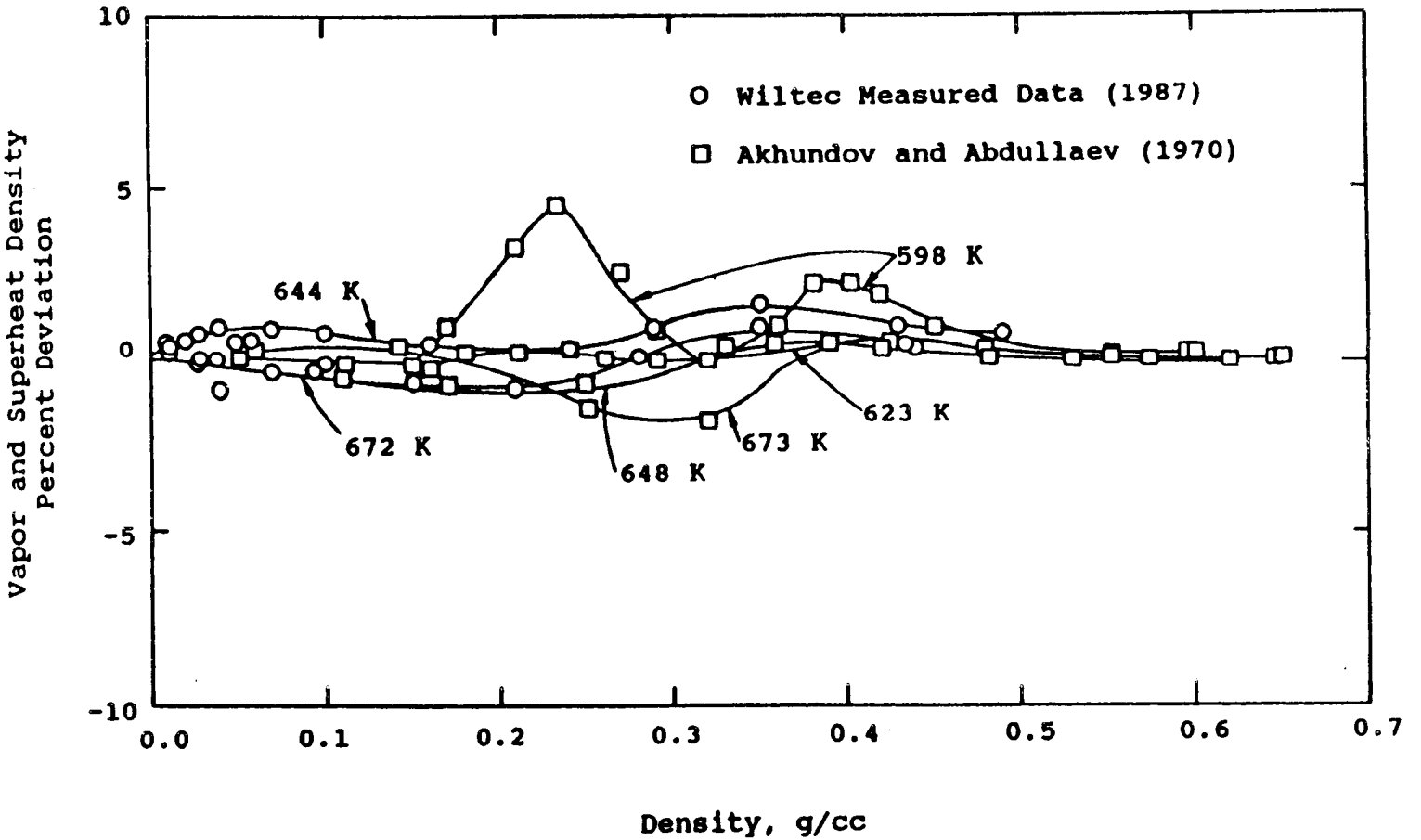

Figure 5. Deviations in Calculated and Measured or Literature Density Data of Toluene in Vapor and Superheat Regions.

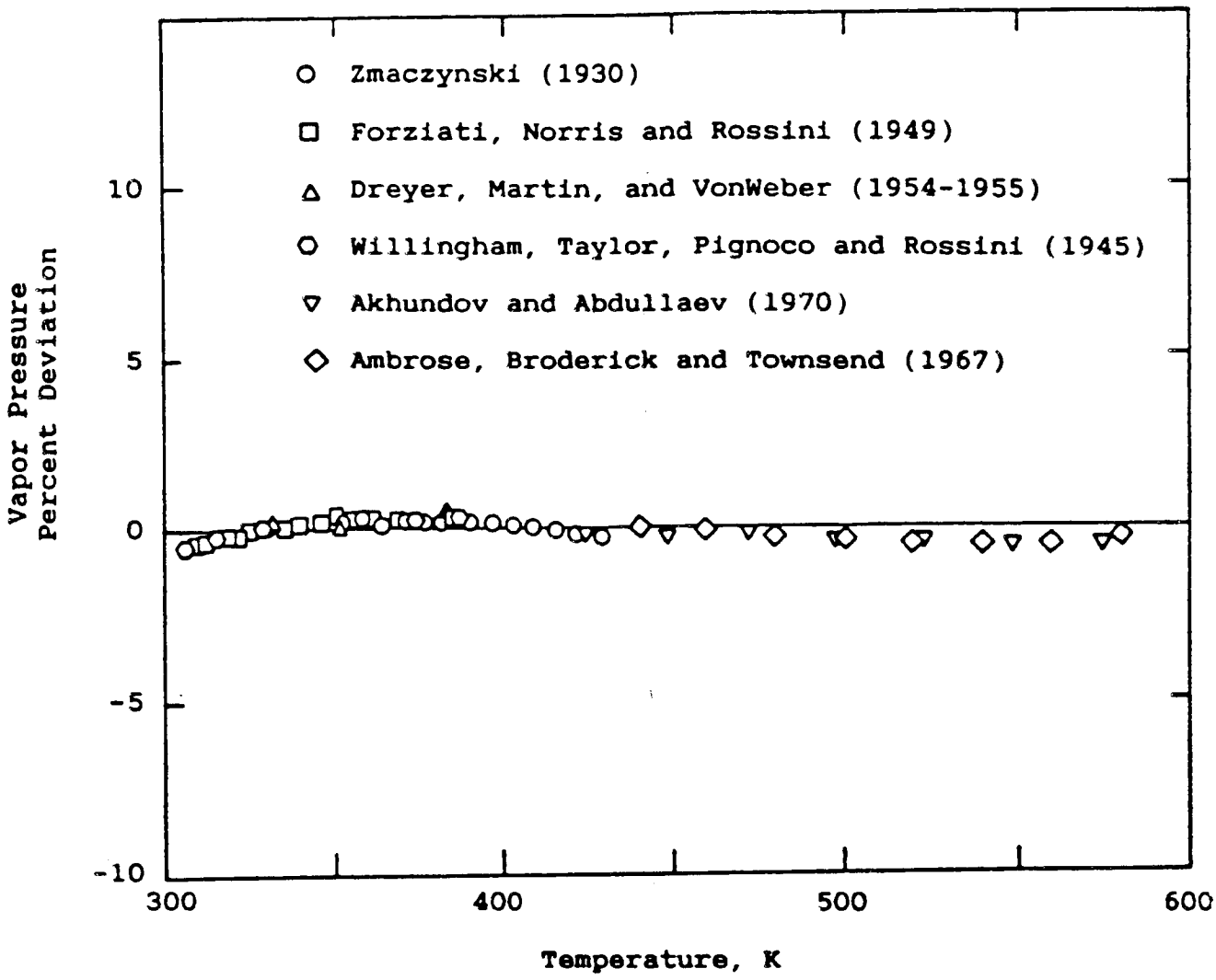

Figure 6. Deviations Between Calculated and Literature Vapor Pressure Data of Toluene.

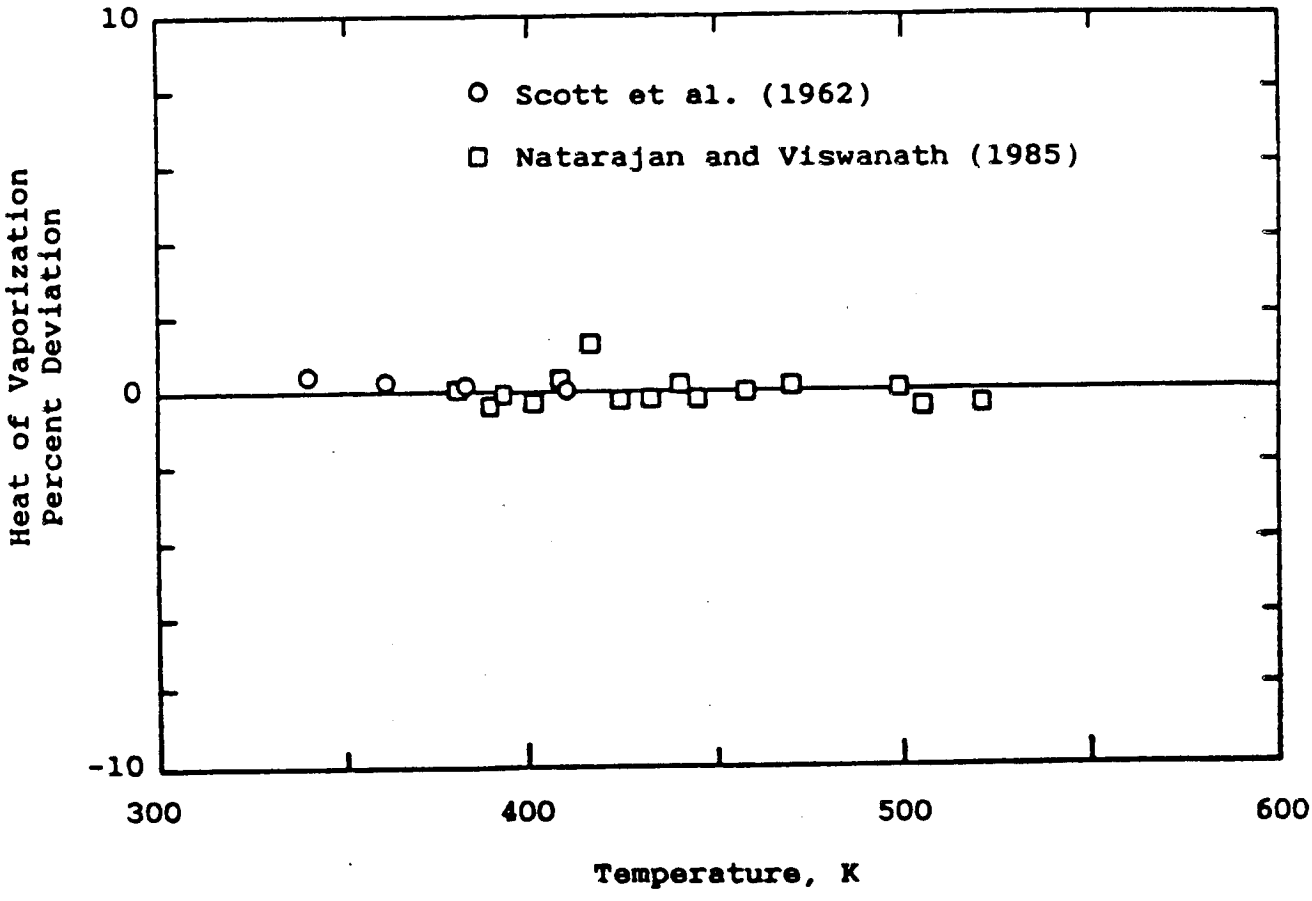

Figure 7. Deviations in Calculated and Literature Heats of Vaporization of Toluene.

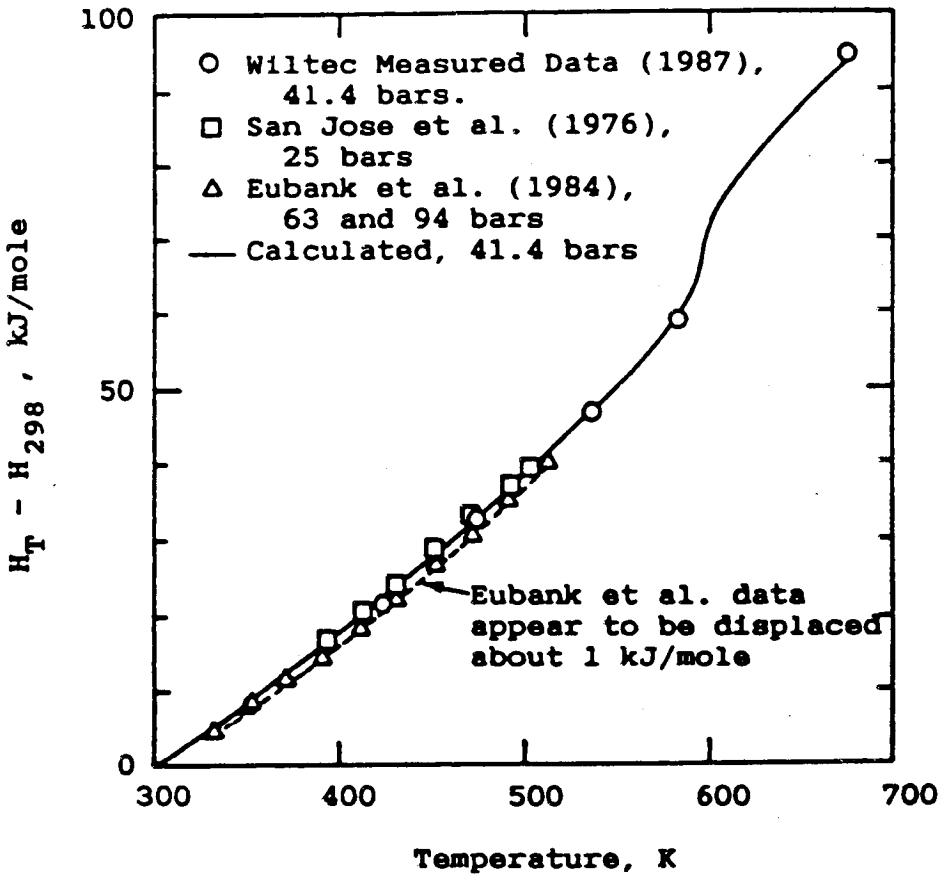

Figure 8. Enthalpy of Liquid Toluene, Comparison of Calculated With Measured and Literature Data (H_T and H_{298} at same Pressure).

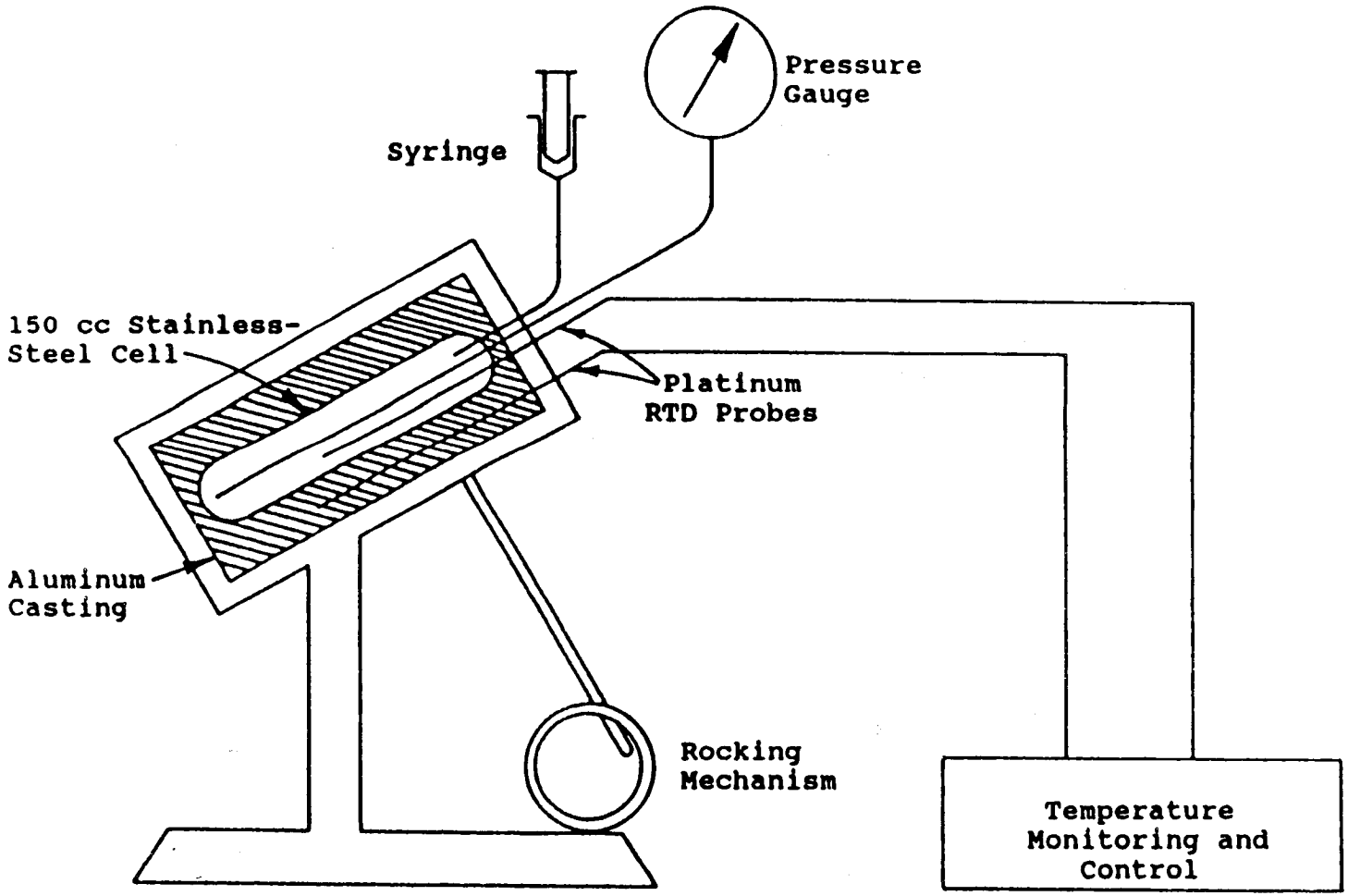

Figure 9. Schematic of Liquid Density Apparatus.

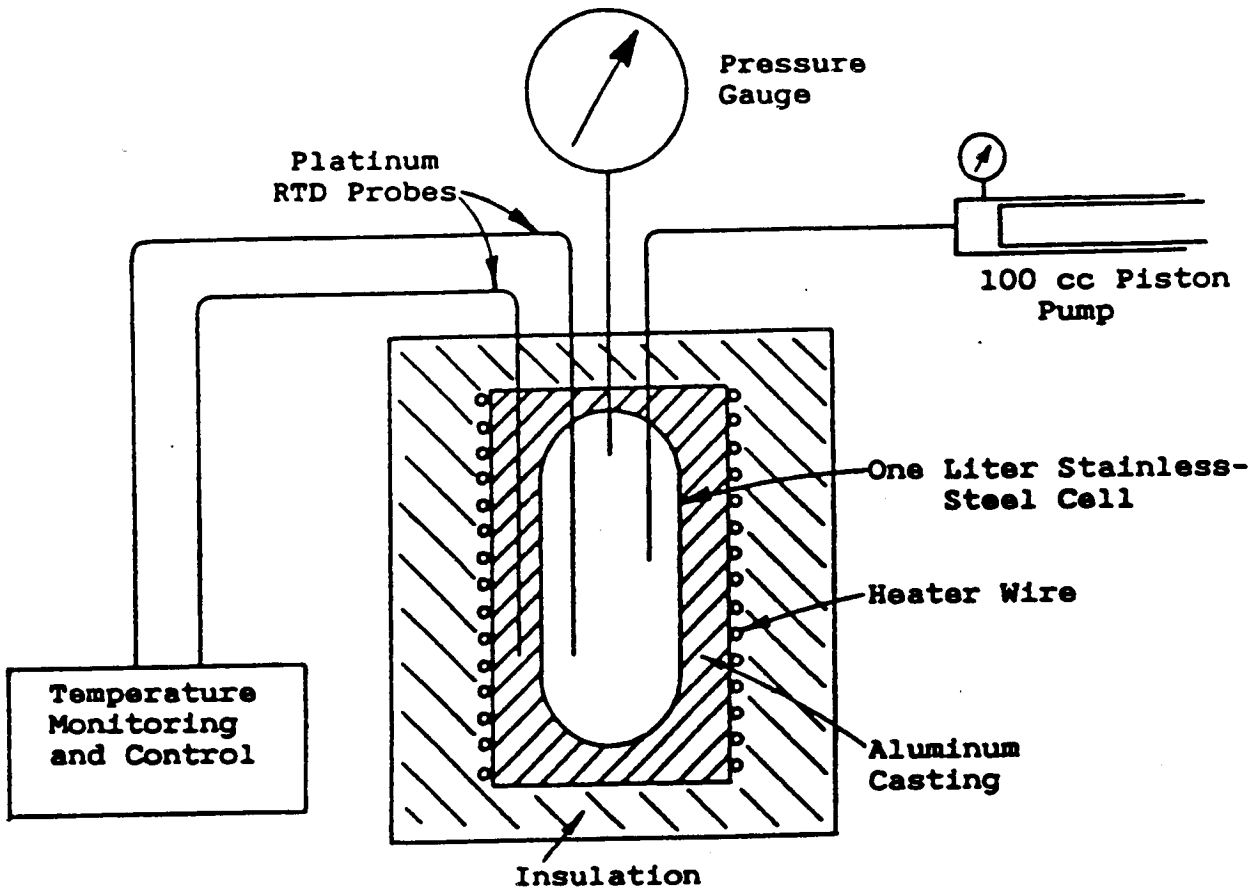

Figure 10. Schematic of PVT Apparatus.

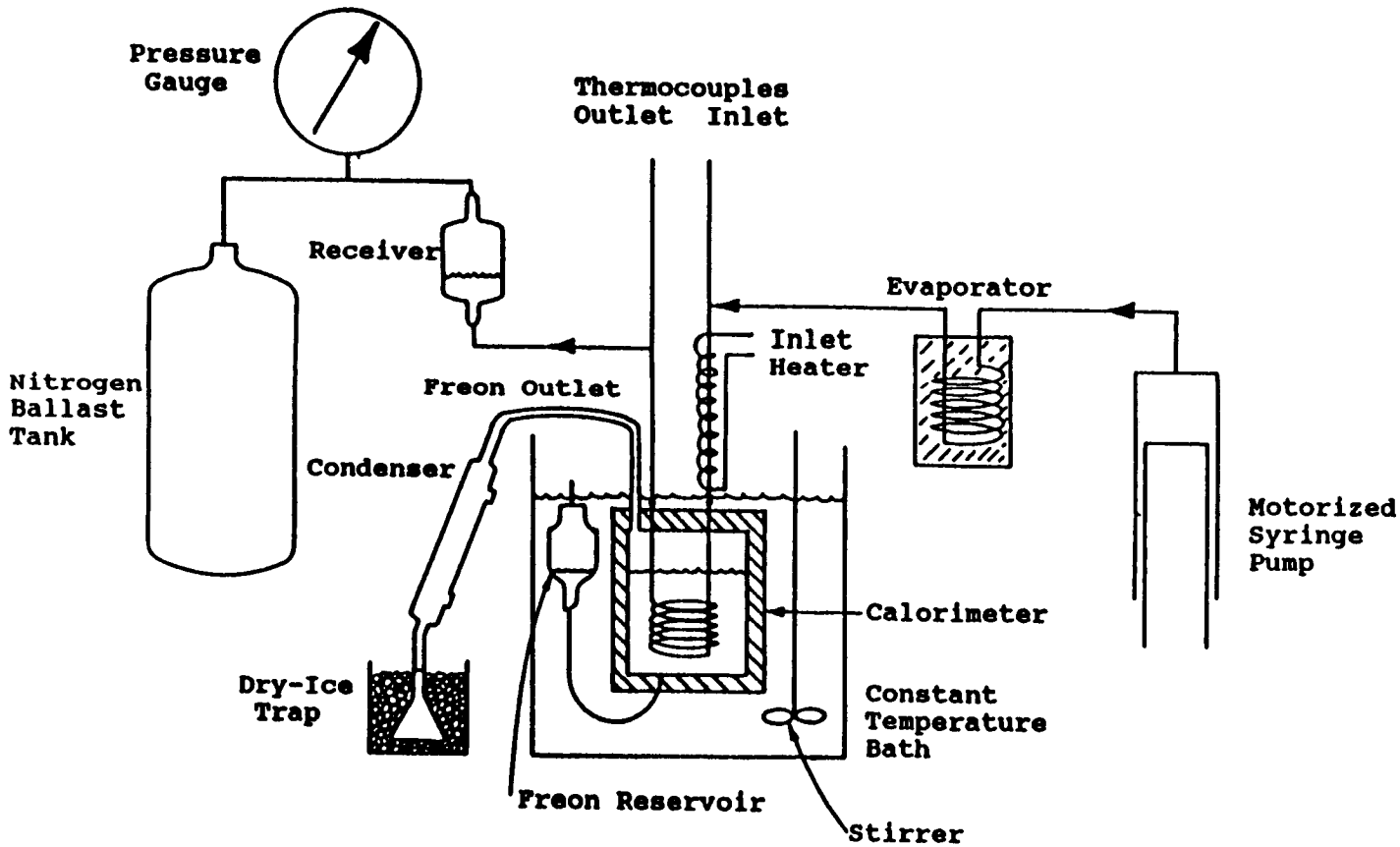

Figure 11. Schematic of Isobaric Enthalpy Apparatus

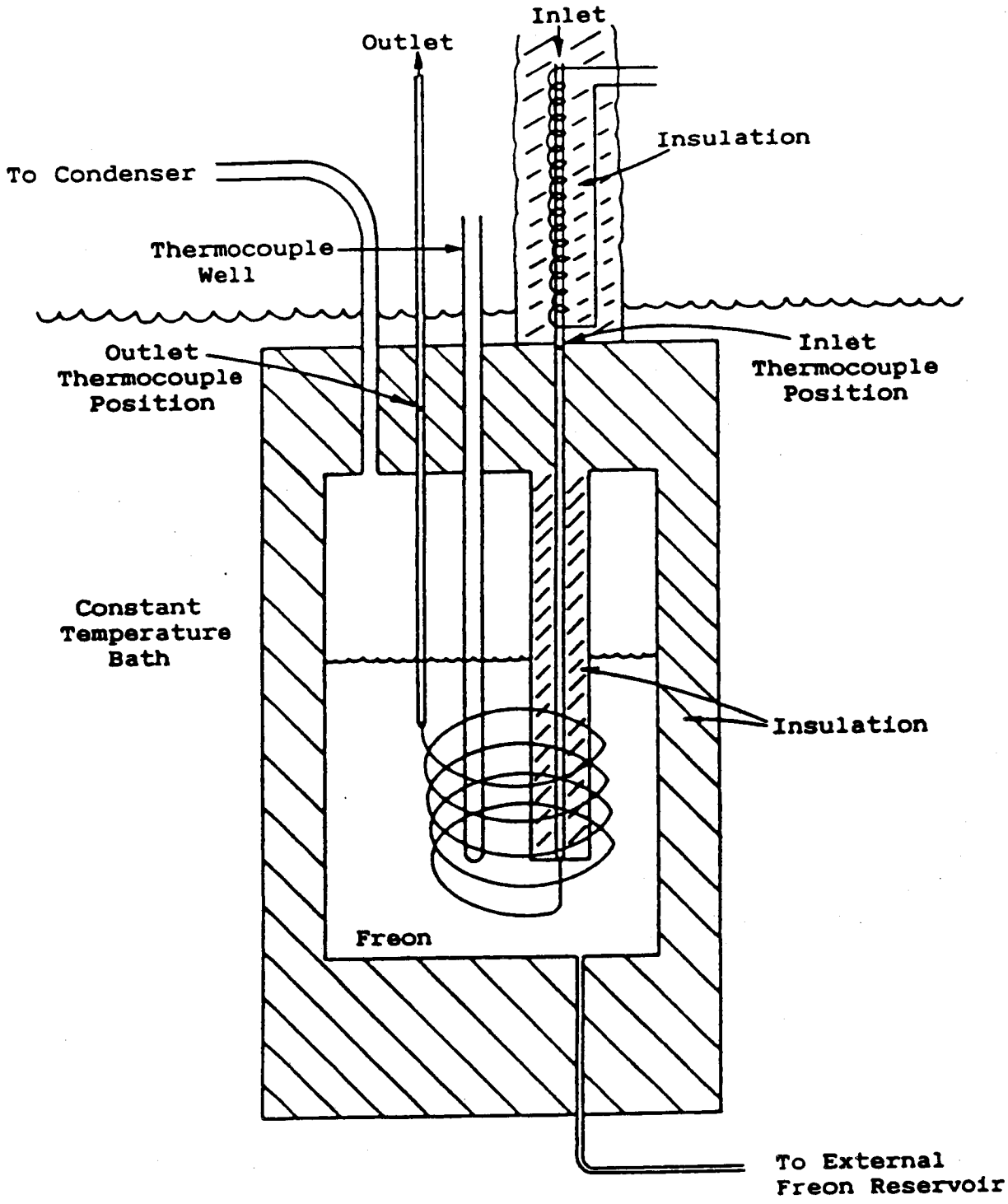

Figure 12. Detail of Isobaric Calorimeter

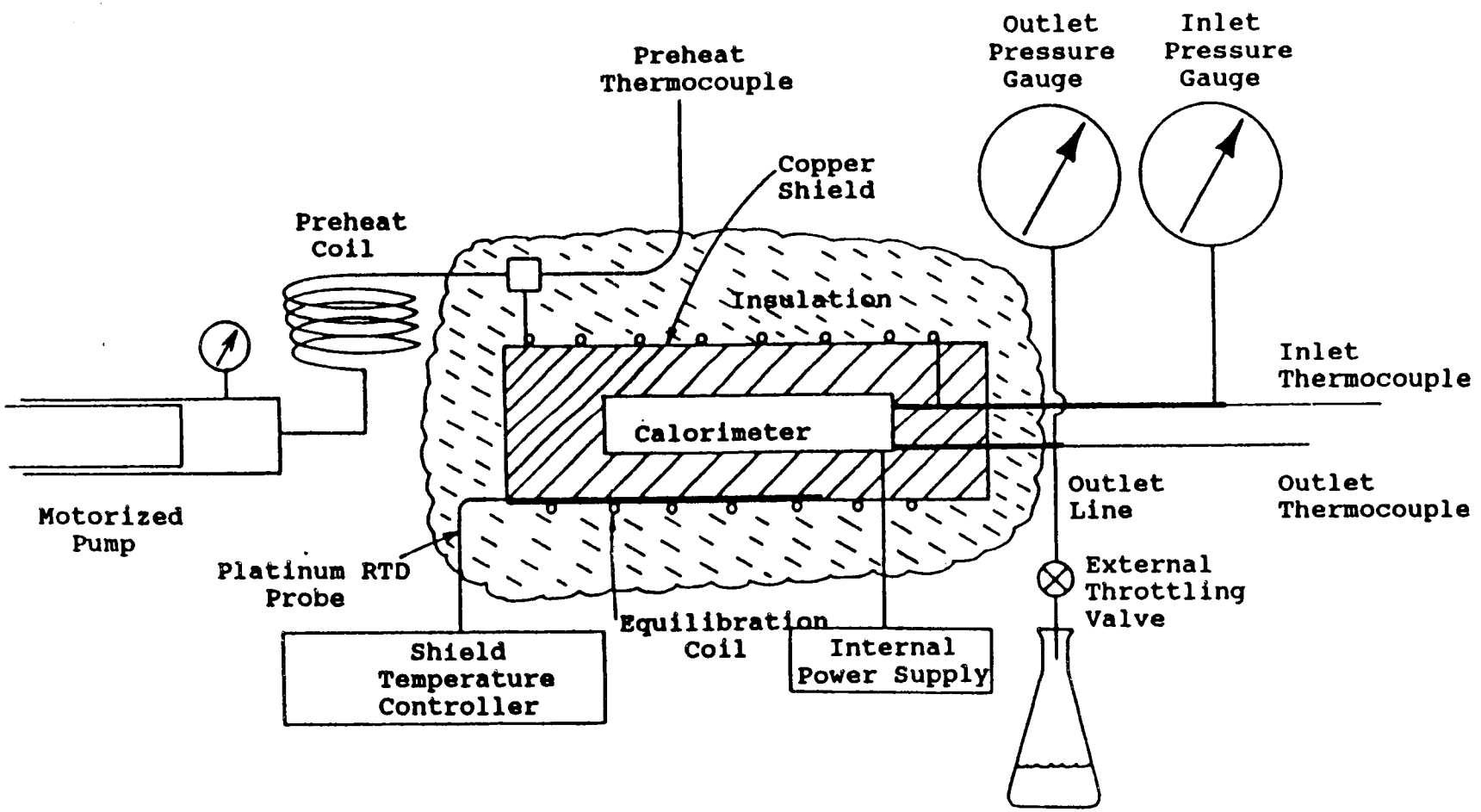

Figure 13. Schematic of Isothermal Calorimeter.

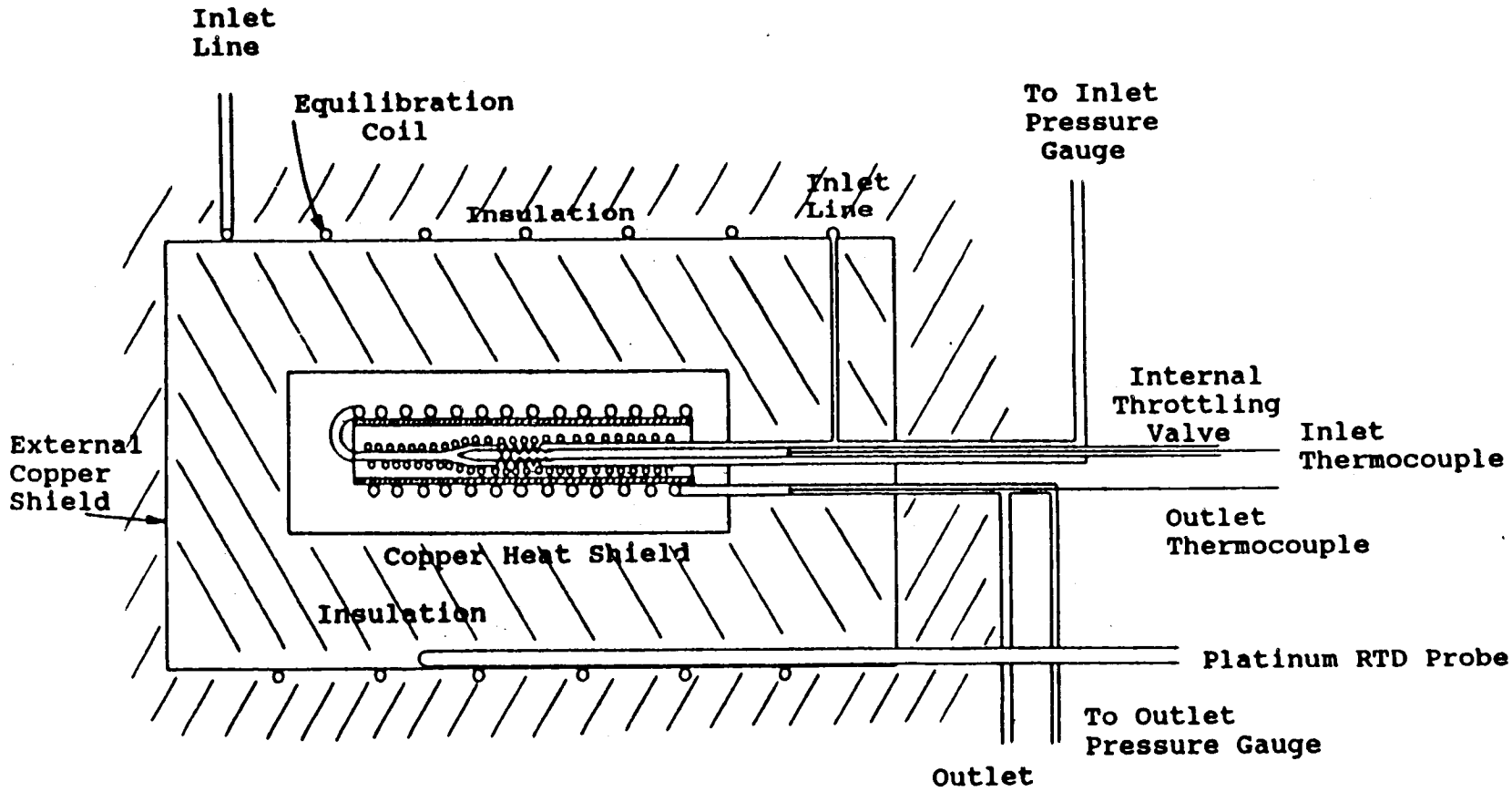

Figure 14. Detail of Isothermal Calorimeter.

Appendix A

Analytical summaries and selected analyses of original and partially degraded toluene after various periods of high temperature exposure.

4.2.2.1

U.S. Department of Energy
ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439
Telephone 312/972-

February 4, 1987

Mr. Dana Ragaller
Sundstrand Aviation Operations
4747 Harrison Avenue
P. O. Box 7002
Rockford, Illinois 61125-7002

Subject: Project No. 85426, Toluene Sample Degradation

Dear Dana:

Attached is a report on analysis of the 2996-hour toluene sample from your test loop. If you have any questions, please feel free to call me.

Sincerely yours,

Roger L. Cole

Roger L. Cole
Principal Investigator

cc: J. Demirgian (ACL)
J. Lazar (ENG)
W. Schertz (EES)

Analysis of Sundstrand Toluene Sample - 750°F, 2996 hr.

The toluene sample received from Sundstrand was analyzed using the exact gas chromatographic procedures described previously; although due to an ongoing project a different column had to be used in the GC/MS. GC analysis was also supplemented by GC/MS analysis because of the possibility of air incursion in the ORC loop. The components were reidentified to determine if any oxygen containing components were present.

GC/MS analysis

The total ion chromatogram and mass spectra and identifications of the components are presented in Appendix 1. Identifications were in agreement with previous results.

A special effort was made to find oxygen containing material such as benzaldehyde. No large amounts of any oxygen containing material were found. GC/MS identification of benzaldehyde was attemped. A spectrum was obtained of a component in very low concentration which has the major masses in approximately the correct ratio. Positive identification can not be made because the concentration of the component is low and there is interference from other eluting components. The column used for GC/MS analysis has a different polarity than that used for GC analysis; this will slightly change the elution order. The possible benzaldehyde component eluted at 19.4 min. It's actual MS as well as a background subtracted spectrum are presented in Appendix 1. GC retention index search showed this component to be benzaldehyde at 8.5 ppm concentration. In any event the amount of benzaldehyde present, if any, is very low.

GC analysis

Total degradation products present consisted of less than 1% by weight of the sample. The increase of some of the major degradation products is not linear. In the previous sample taken at 1446 hours versus the current 2996 hour sample, the concentration of bibenzyl increased from 246.8 to 375.4 ppm. The benzene concentration has increased slightly. However some of the impurities such as p-xylene and ethylbenzene have decreased in concentration. Those components not present in the initial toluene sample but formed in the course of degradation have increased from 700.7 to 1212.9 ppm. This number is computed by totaling the concentration of all components eluting after the xylenes and not present in the initial toluene charge.

A replotted chromatogram is presented in Figure 1. The retention index report for the sample is presented in Table 1. The retention index reports for the previously analyzed samples at 0, 541, and 1413 hours are presented in Appendix 2. The benzene values and total concentrations have been corrected due to the initial error in benzene concentrations. These new reports supercede all previous reports.

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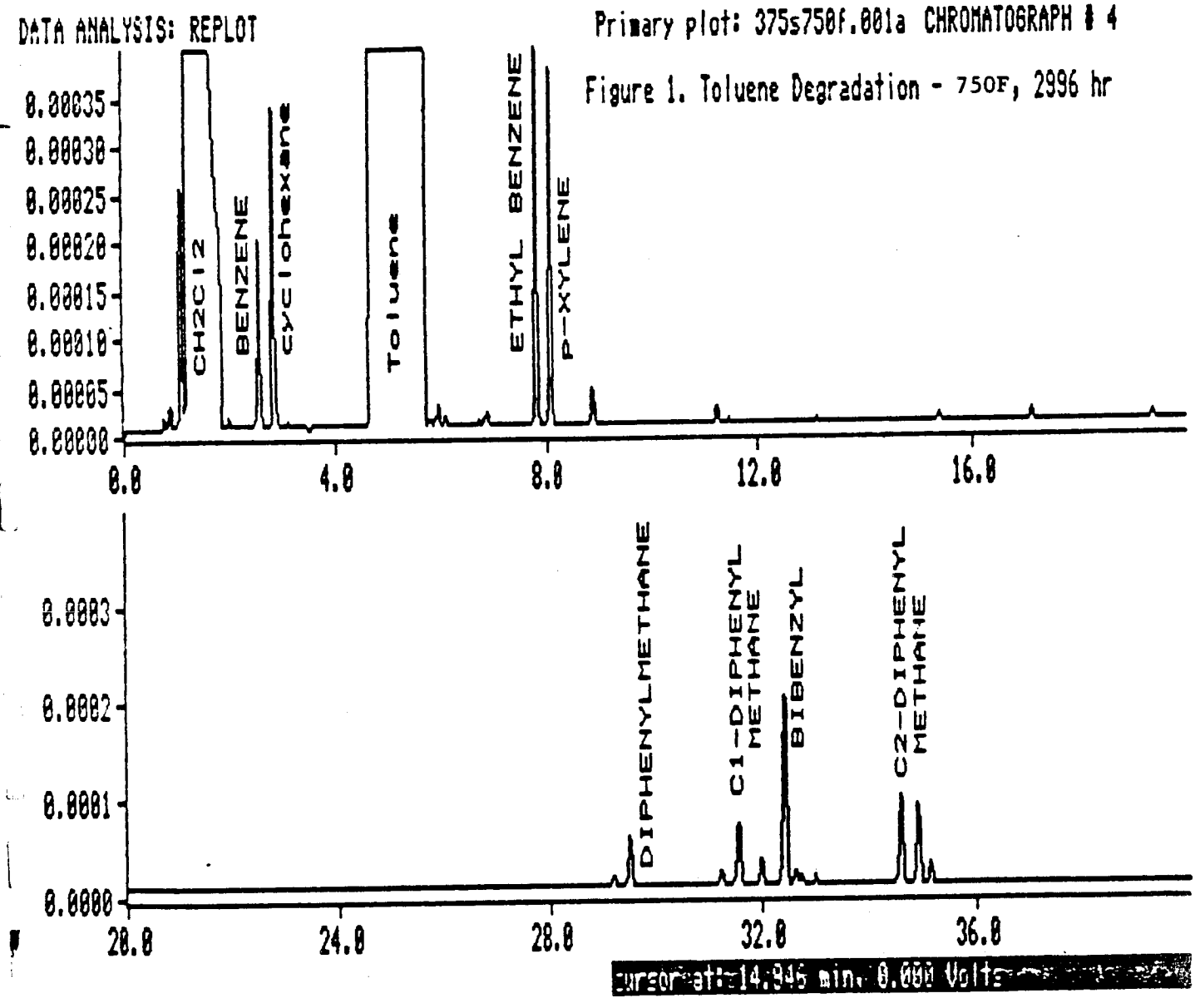

Figure 1. Toluene Degradation - 750F, 2996 hr

Table 1. Retention Index Report for 2996 hour Sample

RRI REPORT FOR 37501 S750F2996H
REPORT BASED ON STANDARD FILE 37401.RF

REPORT PARAMETERS

MINIMUM PEAK AREA : 0
MAXIMUM PEAK AREA : 1E+07
PEAK START TIME : 0
PEAK RECOGNITION WINDOW : .1
AMOUNT INJECTED : 2 UL
DILUTION FACTOR : 10

REFERENCE PEAK DATA

REFERENCE PEAK # 1
COMPOUND NAME : BENZENE
RETENTION INDEX # 200
RETENTION TIME : 2.515 MIN
RESPONSE FACTOR : 17.91 AREA COUNTS/NG

REFERENCE PEAK # 2
COMPOUND NAME : NAPHTHALENE
RETENTION INDEX # 400
RETENTION TIME : 20.46 MIN
RESPONSE FACTOR : 16.49 AREA COUNTS/NG

REFERENCE PEAK # 3
COMPOUND NAME : PHENANTHRENE
RETENTION INDEX # 600
RETENTION TIME : 40.228 MIN
RESPONSE FACTOR : 13.51 AREA COUNTS/NG

REFERENCE PEAK # 4
COMPOUND NAME : CHRYSENE
RETENTION INDEX # 800
RETENTION TIME : 56.836 MIN
RESPONSE FACTOR : 13.51 AREA COUNTS/NG

RESPONSE FACTORS

RETENTION TIMES	RESPONSE FACTOR
0 - 9 MIN	17.91
9 -20 MIN	13.904
20-30 MIN	16.49
30-47 MIN	14.7975
47- MIN	14.7975

TEMPERATURE PROGRAM : (40 / 2 - 280 / 15) 4

RRI REPORT

SAMPLE:S750F2996H
DISK FILE : 37501
GC RUN: 12 3 86

	ARI	CONC PPM	RT CORR	RT	AREA
BENZENE	200	218.9	2.52	2.52	680
	236	11.1	5.78	5.78	35
	238	24.5	5.91	5.91	76
	239	12.4	6.05	6.05	38
	246	5.2	6.69	6.69	16
	248	17.7	6.83	6.83	55
ETHYLBENZENE	259	410.0	7.76	7.76	1273
P-XYLENE	262	433.7	8.04	8.04	1347
O-XYLENE	271	46.6	8.88	8.88	145
C3-BENZENE	296	31.5	11.15	11.24	76
?BENZALDEHYDE?	299	8.5	11.37	11.46	20
	317	7.9	13.02	13.10	19
C4-BENZENE	343	19.6	15.33	15.38	47
	362	27.3	17.09	17.13	66
C2-STYRENE	388	19.3	19.41	19.42	47
	488	19.1	29.19	29.19	5
DIPHENYLMETHANE	491	80.9	29.49	29.49	23.
C1-BIPHENYL	509	31.1	31.23	31.23	80
C1-BIPHENYL	512	133.8	31.54	31.54	343
C1-DIPHENYLMETHANE	516	57.0	31.97	31.97	146
BIBENZYL	521	375.4	32.41	32.41	963
C1-DIPHENYLMETHANE	523	30.0	32.61	32.61	77
C1-DIPHENYLMETHANE	524	16.4	32.74	32.74	42
C1-DIPHENYLMETHANE	527	16.7	32.98	32.98	43
C2-BIPHENYL	543	171.8	34.57	34.57	441
C2-BIPHENYL	546	163.0	34.89	34.89	418
4-4-C2-BIPHENYL	548	38.8	35.13	35.13	100

TOTAL CONCENTRATION = 2428.23 PPM
NO. OF INTERPRETTED PEAKS = 28
TOTAL NO. OF PEAKS = 30

TOLUENE DATA :

RT= 5.64 AREA= 3051660
ARI= 235 CONC= 982633

RRI REPORT

SAMPLE:S750F1403H
DISK FILE : 35201
GC RUN: 8 29 86

	ARI	CONC PPM	RT CORR	RT	AREA
	142	179.8	1.80	1.80	593
BENZENE	200	182.6	2.55	2.55	602
	202	3.2	2.71	2.71	10
	206	4.9	3.13	3.13	16
	212	1.7	3.61	3.61	6
	236	5.9	5.79	5.79	20
	237	7.7	5.83	5.83	25
	238	29.7	5.96	5.96	98
	240	16.9	6.10	6.10	56
	241	3.0	6.24	6.24	10
	244	5.5	6.53	6.53	18
	247	7.7	6.73	6.73	25
	248	22.1	6.87	6.87	73
ETHYLBENZENE	259	450.8	7.80	7.80	1487
P-XYLENE	262	475.2	8.08	8.08	1567
O-XYLENE	271	49.5	8.91	8.91	163
	274	5.7	9.19	9.19	15
	276	5.8	9.37	9.37	15
	278	4.2	9.55	9.55	11
	287	2.5	10.33	10.32	7
	289	2.5	10.50	10.49	6
	297	20.5	11.27	11.26	53
	300	7.3	11.50	11.48	19
	301	3.3	11.59	11.58	8
	318	10.2	13.13	13.12	26
	328	2.9	14.04	14.03	7
C1-STYRENE	334	2.2	14.56	14.55	6
C4-BENZENE	344	10.1	15.41	15.40	26
	347	4.8	15.72	15.71	13
	350	3.0	15.97	15.97	8
	363	36.2	17.15	17.14	93
	371	3.3	17.85	17.85	9
C2-STYRENE	388	11.0	19.44	19.44	28
	488	10.1	29.19	29.19	31
DIPHENYLMETHANE	491	41.3	29.49	29.49	126
C1-BIPHENYL	509	14.7	31.22	31.22	42
C1-BIPHENYL	512	68.9	31.54	31.54	195
C1-DIPHENYLMETHANE	516	29.8	31.97	31.97	84
BIBENZYL	521	246.8	32.40	32.40	698
C1-DIPHENYLMETHANE	523	15.1	32.60	32.60	43
C1-DIPHENYLMETHANE	524	7.6	32.73	32.73	21
C1-DIPHENYLMETHANE	527	7.5	32.98	32.98	21

C2-BIPHENYL	543	86.9	34.55	34.55	246
C2-BIPHENYL	546	82.0	34.88	34.88	232
4-4-C2-BIPHENYL	548	19.1	35.12	35.12	54
C3-BIPHENYL	562	2.5	36.45	36.45	7

TOTAL CONCENTRATION = 2214.0 PPM
NO. OF INTERPRETTED PEAKS = 47
TOTAL NO. OF PEAKS = 49

TOLUENE DATA :

RT= 5.70 AREA= 3575960
ARI= 235 CONC= 1084260

RRI REPORT

SAMPLE:S750F541H
DISK FILE : 36702
GC RUN: 7 15 86

	ARI	CONC PPM	RT CORR	RT	AREA
	57	2.6	0.73	0.73	9
	59	5.2	0.76	0.76	18
	64	46.7	0.81	0.81	162
	69	20.4	0.88	0.88	71
	142	122.9	1.81	1.81	426
BENZENE	200	117.2*	2.56	2.56	8746
	202	5.1	2.72	2.72	18
	236	5.2	5.80	5.80	18
	237	6.2	5.83	5.83	22
	238	26.9	5.96	5.96	93
	240	16.4	6.10	6.10	57
	244	6.9	6.54	6.54	24
	247	7.4	6.73	6.73	26
	248	18.4	6.87	6.87	64
ETHYLBENZENE	259	392.6	7.80	7.80	1360
P-XYLENE	262	413.6	8.07	8.07	1432
O-XYLENE	271	41.0	8.90	8.90	142
	274	5.7	9.17	9.17	15
	276	24.8	9.34	9.34	67
C3-BENZENE	296	7.4	11.14	11.25	20
	317	10.1	13.02	13.10	27
	362	34.2	17.08	17.12	92
DIPHENYLMETHANE	491	14.2	29.46	29.46	46
C1-BIPHENYL	512	23.1	31.50	31.50	73
TOLUYLPHENYLMETHANE	516	9.8	31.93	31.93	31
BIBENZYL	521	109.9	32.36	32.36	348
C2-BIPHENYL	543	28.8	34.51	34.51	91
C2-BIPHENYL	546	27.5	34.83	34.83	87
4-4-C2-BIPHENYL	548	6.3	35.08	35.08	20

TOTAL CONCENTRATION = 1556.4 PPM*
NO. OF INTERPRETTED PEAKS = 30
TOTAL NO. OF PEAKS = 33

TOLUENE DATA :

RT= 5.71 AREA= 3398130
ARI= 235 CONC= 981325

*value corrected for GC/MS benzene quantitation

RRI REPORT

SAMPLE:S750FOH
DISK FILE : 36802
GC RUN: 7 15 86

	ARI	CONC PPM	RT CORR	RT	AREA
	60	1.1	0.77	0.77	4
	64	99.7	0.82	0.82	345
	69	57.2	0.89	0.89	198
	81	1.7	1.03	1.03	6
BENZENE	200	80.2*	2.57	2.57	7962
	202	6.3	2.73	2.73	22
	206	9.0	3.14	3.14	31
	236	4.5	5.82	5.82	16
	237	5.8	5.85	5.85	20
	238	26.6	5.98	5.98	92
	240	17.2	6.12	6.12	59
	245	7.8	6.55	6.55	27
	247	8.5	6.75	6.75	29
	248	20.4	6.89	6.89	71
ETHYLBENZENE	259	369.4	7.81	7.81	1279
P-XYLENE	262	386.4	8.08	8.08	1338
O-XYLENE	271	38.0	8.92	8.92	132
	274	5.3	9.18	9.18	14
	276	81.8	9.35	9.35	221
	318	9.5	13.08	13.11	26
	363	32.0	17.11	17.13	86

TOTAL CONCENTRATION = 1268.2 PPM*
NO. OF INTERPRETTED PEAKS = 22
TOTAL NO. OF PEAKS = 25

TOLUENE DATA :

RT= 5.73 AREA= 3438890
ARI= 235 CONC= 993096

*value corrected by GC/MS benzene quantitation

TABLE 6

LIQUID ANALYSIS DATA
WEIGHT %

TIME, HRS	"0"	ARGONNE "0"	187	512	ARGONNE 541	800	1403	ARGONNE 1403
ELUTE BEFORE BENZENE	0.001	0.016	0.000	0.010	0.020	0.004	0.006	.018
BENZENE	0.001	0.008	0.003	0.005	0.012	0.006	0.014	0.018
BENZALDEHYDE	0.000	0.000	0.000	0.001	0.000	0.001	0.002	0.000
OTHER ONE RING COMPOUNDS	0.127	0.103	0.123	0.121	0.102	0.119	0.116	0.122
BIPHENYL	0.002	0.000	0.013	0.002	0.000	0.013	0.002	0.001
BIBENZYL	0.002	0.000	0.009	0.016	0.011	0.020	0.030	0.025
OTHER TWO RING COMPOUNDS	0.019	0.000	0.061	0.040	0.011	0.059	0.036	0.038
THREE RING OR HIGH BOILERS	0.011	0.000	0.001	0.010	0.000	0.001	0.002	0.000
TOTAL NON-TOLUENE	0.163	0.127	0.210	0.205	0.156	0.223	0.208	0.222

NOTE: EACH DATA POINT REPORTED REPRESENTS THE AVERAGE OF THREE READINGS.

Similar to SAMPLE #1
REAGENT GRADE
TOLUENE

TABLE 6 (continued)

LIQUID ANALYSIS DATA
WEIGHT %

TIME, HRS	1713	2001	2093	2550	2604	LeRC 2996	Argonne 2996	2996	850°F #1
ELUTE BEFORE BENZENE	0.006	0.007	0.007	0.006	0.008			0.008	
BENZENE	0.018	0.018	0.019	0.018	0.020			0.019	
BENZALDEHYDE	0.003	0.003	0.004	0.006	0.008			0.004	
OTHER ONE RING COMPOUNDS	0.115	0.119	0.119	0.133	0.119			0.123	
BIPHENYL	0.007	0.008	0.008	0.002	0.005			0.002	
BIBENZYL	0.034	0.036	0.039	0.051	0.048			0.052	
OTHER TWO RING COMPOUNDS	0.047	0.054	0.052	0.062	0.057			0.105	
3-RING AND HIGHER	0.002	0.009	0.002	0.002	0.000			0.003	
TOTAL NON-TOLUENE	0.231	0.254	0.250	0.280	0.265			0.317	

TABLE 6 (continued)

LIQUID ANALYSIS DATA
WEIGHT %

TIME, HRS	3000	3164	850° #1	3168	3381	850°F #3	3385	3410
ELUTE BEFORE BENZENE	0.008	0.009	↓	0.009	0.008	↓	0.007	
BENZENE	0.019	0.021		0.021	0.021		0.020	
BENZALDEHYDE	0.004	0.005		0.005	0.005		0.005	
OTHER ONE RING COMPOUNDS	0.118	0.122		0.119	0.121		0.119	
BIPHENYL	0.003	0.003		0.004	0.002		0.003	
BIBENZYL	0.054	0.055		0.055	0.061		0.058	
OTHER TWO RING COMPOUNDS	0.088	0.087		0.081	0.095		0.115	
3-RING AND HIGHER	0.001	0.001		0.007	0.001		0.001	
TOTAL NON-TOLUENE	0.296	0.303		0.294	0.313		0.327	

SIMILAR to SAMPLE #2
PARTIALLY DEGRADED
TOLUENE

Appendix B

Thermodynamic Tables

I. Toluene

II. Partially Degraded Toluene

III. P-h and T-s diagrams of Toluene

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
60.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	-0.032	-0.025	-0.014	0.009	0.078	0.192	0.423	0.653	0.883	1.114	1.345	1.576	1.808	2.040	2.272	2.738
	s	0.00002	0.00002	0.00000	-0.00002	-0.00009	-0.00020	-0.00043	-0.00066	-0.00089	-0.00111	-0.00134	-0.00156	-0.00178	-0.00200	-0.00222	-0.00266
	v	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	d	54.4885	54.4894	54.4911	54.4942	54.5036	54.5196	54.5511	54.5823	54.6135	54.6445	54.6751	54.7057	54.7360	54.7661	54.7962	54.8555
70.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	4.019	4.026	4.038	4.060	4.129	4.243	4.471	4.699	4.928	5.157	5.387	5.617	5.846	6.077	6.308	6.770
	s	0.00775	0.00774	0.00773	0.00770	0.00763	0.00752	0.00728	0.00705	0.00682	0.00660	0.00637	0.00614	0.00592	0.00569	0.00547	0.00502
	v	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	d	54.1627	54.1636	54.1652	54.1686	54.1785	54.1949	54.2279	54.2605	54.2927	54.3249	54.3569	54.3886	54.4202	54.4515	54.4827	54.5443
80.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	8.126	8.133	8.143	8.166	8.234	8.347	8.574	8.800	9.027	9.255	9.482	9.710	9.939	10.168	10.398	10.856
	s	0.01543	0.01542	0.01541	0.01538	0.01531	0.01519	0.01496	0.01472	0.01449	0.01426	0.01403	0.01380	0.01357	0.01334	0.01312	0.01267
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.018
	d	53.8345	53.8354	53.8373	53.8407	53.8511	53.8681	53.9022	53.9363	53.9699	54.0034	54.0367	54.0697	54.1024	54.1349	54.1672	54.2315
90.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	12.284	12.292	12.303	12.325	12.392	12.504	12.729	12.953	13.179	13.404	13.631	13.857	14.084	14.312	14.538	14.995
	s	0.02306	0.02305	0.02304	0.02302	0.02295	0.02283	0.02259	0.02235	0.02211	0.02188	0.02164	0.02141	0.02118	0.02095	0.02072	0.02026
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	53.5041	53.5051	53.5068	53.5105	53.5214	53.5392	53.5747	53.6101	53.6451	53.6799	53.7145	53.7489	53.7827	53.8166	53.8504	53.9169
100.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	16.496	16.502	16.513	16.536	16.602	16.713	16.935	17.159	17.382	17.606	17.830	18.054	18.279	18.506	18.731	19.185
	s	0.03065	0.03064	0.03063	0.03061	0.03054	0.03041	0.03017	0.02993	0.02969	0.02945	0.02922	0.02898	0.02874	0.02851	0.02828	0.02782
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	53.1713	53.1726	53.1744	53.1780	53.1894	53.2079	53.2450	53.2817	53.3183	53.3545	53.3904	53.4262	53.4616	53.4965	53.5315	53.6005
110.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	20.756	20.763	20.774	20.796	20.862	20.973	21.192	21.414	21.635	21.856	22.079	22.302	22.525	22.749	22.973	23.423
	s	0.03820	0.03819	0.03818	0.03815	0.03808	0.03796	0.03771	0.03747	0.03722	0.03698	0.03674	0.03650	0.03626	0.03603	0.03579	0.03532
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	52.8365	52.8377	52.8396	52.8435	52.8551	52.8745	52.9132	52.9513	52.9894	53.0272	53.0646	53.1015	53.1383	53.1748	53.2113	53.2829
120.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	25.067	25.073	25.085	25.106	25.171	25.280	25.498	25.717	25.936	26.156	26.377	26.597	26.819	27.041	27.264	27.710
	s	0.04570	0.04569	0.04568	0.04565	0.04558	0.04545	0.04520	0.04496	0.04471	0.04446	0.04422	0.04398	0.04374	0.04350	0.04326	0.04278
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	52.4994	52.5005	52.5025	52.5068	52.5189	52.5391	52.5794	52.6191	52.6587	52.6979	52.7367	52.7754	52.8135	52.8515	52.8891	52.9636
130.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	200.127	29.431	29.441	29.464	29.528	29.636	29.853	30.068	30.285	30.504	30.722	30.941	31.160	31.380	31.601	32.043
	s	0.34414	0.05315	0.05313	0.05311	0.05303	0.05290	0.05265	0.05240	0.05215	0.05190	0.05165	0.05140	0.05116	0.05092	0.05067	0.05019
	v	34.042	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0294	52.1614	52.1636	52.1676	52.1805	52.2015	52.2431	52.2850	52.3262	52.3666	52.4071	52.4473	52.4871	52.5266	52.5656	52.6430
140.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	203.164	33.836	33.847	33.868	33.933	34.038	34.252	34.467	34.682	34.897	35.114	35.330	35.548	35.766	35.984	36.423
	s	0.34925	0.06055	0.06054	0.06051	0.06044	0.06031	0.06005	0.05979	0.05954	0.05929	0.05904	0.05879	0.05854	0.05829	0.05805	0.05756
	v	34.635	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0289	51.8199	51.8221	51.8266	51.8396	51.8619	51.9053	51.9484	51.9912	52.0337	52.0757	52.1176	52.1588	52.1998	52.2404	52.3207

T in F, P in psia, h in Btu/lb, s in Btu/lb R, v in cubic feet/lb, d in lb/cubic foot

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
150.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	206.250	38.288	38.299	38.319	38.383	38.488	38.699	38.910	39.124	39.337	39.551	39.766	39.980	40.197	40.413	40.847
	s	0.35435	0.06792	0.06790	0.06788	0.06780	0.06767	0.06740	0.06714	0.06689	0.06663	0.06637	0.06612	0.06587	0.06562	0.06537	0.06488
	v	35.230	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0284	51.4760	51.4784	51.4831	51.4968	51.5197	51.5650	51.6103	51.6547	51.6988	51.7425	51.7858	51.8290	51.8714	51.9137	51.9971
160.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	209.385	42.786	42.796	42.816	42.880	42.982	43.192	43.401	43.610	43.822	44.033	44.245	44.458	44.672	44.886	45.316
	s	0.35945	0.07523	0.07522	0.07519	0.07511	0.07498	0.07471	0.07445	0.07419	0.07393	0.07367	0.07341	0.07315	0.07290	0.07265	0.07215
	v	35.824	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0279	51.1298	51.1323	51.1371	51.1513	51.1755	51.2224	51.2694	51.3161	51.3618	51.4075	51.4525	51.4973	51.5415	51.5854	51.6719
170.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	212.567	212.061	47.339	47.358	47.420	47.522	47.728	47.935	48.142	48.350	48.560	48.769	48.979	49.191	49.403	49.829
	s	0.36455	0.34421	0.08249	0.08246	0.08238	0.08224	0.08197	0.08171	0.08144	0.08118	0.08091	0.08065	0.08039	0.08013	0.07988	0.07937
	v	36.418	14.406	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.019
	d	0.0275	0.0694	50.7837	50.7888	50.8039	50.8288	50.8781	50.9268	50.9752	51.0231	51.0704	51.1174	51.1638	51.2098	51.2553	51.3451
180.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	215.797	215.311	51.925	51.946	52.007	52.107	52.310	52.513	52.718	52.924	53.129	53.336	53.544	53.754	53.962	54.384
	s	0.36964	0.34933	0.08972	0.08969	0.08961	0.08947	0.08920	0.08892	0.08865	0.08838	0.08811	0.08785	0.08758	0.08732	0.08706	0.08655
	v	37.009	14.649	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0270	0.0683	50.4329	50.4377	50.4534	50.4794	50.5308	50.5820	50.6323	50.6820	50.7314	50.7803	50.8287	50.8762	50.9238	51.0171
190.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	219.074	218.608	56.556	56.576	56.636	56.735	56.935	57.135	57.336	57.539	57.742	57.946	58.152	58.357	58.565	58.980
	s	0.37472	0.35445	0.09690	0.09687	0.09679	0.09665	0.09637	0.09609	0.09581	0.09554	0.09527	0.09500	0.09473	0.09446	0.09420	0.09368
	v	37.601	14.893	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0266	0.0671	50.0790	50.0844	50.1007	50.1280	50.1815	50.2346	50.2874	50.3390	50.3906	50.4413	50.4915	50.5413	50.5904	50.6876
200.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	222.400	221.950	61.232	61.251	61.309	61.407	61.603	61.800	61.998	62.197	62.397	62.599	62.801	63.004	63.209	63.621
	s	0.37980	0.35955	0.10404	0.10401	0.10393	0.10378	0.10350	0.10321	0.10293	0.10266	0.10238	0.10211	0.10183	0.10156	0.10130	0.10077
	v	38.193	15.135	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0262	0.0661	49.7224	49.7281	49.7453	49.7734	49.8296	49.8851	49.9398	49.9939	50.0474	50.1003	50.1526	50.2043	50.2554	50.3559
210.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	225.771	225.338	224.601	65.968	66.026	66.121	66.313	66.507	66.703	66.898	67.095	67.293	67.493	67.693	67.895	68.300
	s	0.38487	0.36465	0.34892	0.11111	0.11103	0.11088	0.11059	0.11030	0.11001	0.10973	0.10945	0.10917	0.10889	0.10862	0.10835	0.10781
	v	38.784	15.376	7.571	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0258	0.0650	0.1321	49.3692	49.3867	49.4166	49.4752	49.5330	49.5899	49.6464	49.7021	49.7572	49.8114	49.8653	49.9184	50.0232
220.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	229.189	228.772	228.063	70.730	70.785	70.880	71.069	71.258	71.449	71.641	71.835	72.030	72.225	72.423	72.621	73.021
	s	0.38994	0.36974	0.35405	0.11817	0.11808	0.11793	0.11763	0.11734	0.11705	0.11676	0.11647	0.11619	0.11591	0.11563	0.11535	0.11481
	v	39.374	15.617	7.696	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0254	0.0640	0.1299	49.0069	49.0257	49.0563	49.1174	49.1780	49.2376	49.2964	49.3545	49.4118	49.4686	49.5245	49.5799	49.6885
230.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	232.653	232.251	231.569	75.534	75.588	75.680	75.864	76.049	76.237	76.426	76.616	76.808	77.	77.193	77.389	77.781
	s	0.39500	0.37482	0.35917	0.12519	0.12509	0.12494	0.12464	0.12434	0.12404	0.12375	0.12346	0.12317	0.12288	0.12260	0.12231	0.12176
	v	39.964	15.858	7.820	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0250	0.0631	0.1279	48.6416	48.6613	48.6934	48.7573	48.8207	48.8828	48.9441	49.0047	49.0642	49.1234	49.1817	49.2392	49.3525

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
240.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	236.163	235.775	235.117	80.381	80.435	80.524	80.704	80.885	81.068	81.253	81.439	81.626	81.814	82.005	82.197	82.584
	s	0.40005	0.37990	0.36428	0.13216	0.13207	0.13191	0.13160	0.13130	0.13100	0.13070	0.13040	0.13010	0.12981	0.12952	0.12924	0.12867
	v	40.553	16.097	7.944	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.020	0.020	0.020
	d	0.0247	0.0621	0.1259	48.2728	48.2931	48.3271	48.3939	48.4599	48.5249	48.5887	48.6519	48.7144	48.7761	48.8366	48.8962	49.0140
250.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	239.719	239.345	238.710	85.272	85.324	85.411	85.585	85.762	85.940	86.121	86.303	86.486	86.671	86.857	87.046	87.425
	s	0.40509	0.38496	0.36938	0.13910	0.13901	0.13885	0.13853	0.13822	0.13791	0.13760	0.13730	0.13700	0.13670	0.13641	0.13612	0.13554
	v	41.143	16.339	8.068	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0243	0.0612	0.1239	47.9004	47.9216	47.9571	48.0272	48.0961	48.1642	48.2311	48.2967	48.3619	48.4260	48.4893	48.5514	48.6739
260.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	243.320	242.958	242.346	241.080	90.256	90.340	90.510	90.682	90.855	91.031	91.208	91.387	91.567	91.750	91.934	92.307
	s	0.41013	0.39002	0.37446	0.35826	0.14591	0.14575	0.14542	0.14510	0.14479	0.14447	0.14416	0.14386	0.14355	0.14325	0.14296	0.14237
	v	41.733	16.577	8.191	3.995	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0240	0.0603	0.1221	0.2503	47.5464	47.5837	47.6570	47.7290	47.8002	47.8701	47.9390	48.0068	48.0738	48.1396	48.2045	48.3316
270.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	246.965	246.616	246.025	244.804	95.233	95.314	95.478	95.644	95.812	95.982	96.155	96.329	96.505	96.683	96.864	97.227
	s	0.41516	0.39507	0.37954	0.36340	0.15278	0.15261	0.15228	0.15195	0.15163	0.15131	0.15099	0.15068	0.15037	0.15006	0.14976	0.14916
	v	42.320	16.817	8.314	4.060	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0236	0.0595	0.1203	0.2463	47.1667	47.2057	47.2828	47.3583	47.4328	47.5059	47.5778	47.6488	47.7186	47.7872	47.8546	47.9874
280.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	250.657	250.318	249.747	248.570	100.253	100.330	100.488	100.648	100.811	100.976	101.142	101.312	101.485	101.657	101.832	102.189
	s	0.42019	0.40010	0.38461	0.36852	0.15961	0.15944	0.15910	0.15876	0.15843	0.15810	0.15778	0.15746	0.15715	0.15683	0.15652	0.15592
	v	42.911	17.056	8.437	4.125	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0233	0.0586	0.1185	0.2424	46.7828	46.8239	46.9045	46.9839	47.0619	47.1384	47.2140	47.2878	47.3602	47.4321	47.5027	47.6405
290.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	254.391	254.064	253.512	252.376	105.317	105.391	105.542	105.695	105.851	106.011	106.173	106.337	106.502	106.671	106.842	107.189
	s	0.42520	0.40513	0.38966	0.37363	0.16641	0.16623	0.16589	0.16554	0.16520	0.16487	0.16453	0.16421	0.16388	0.16357	0.16325	0.16263
	v	43.499	17.295	8.559	4.189	0.022	0.022	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0230	0.0578	0.1168	0.2387	46.3941	46.4371	46.5222	46.6057	46.6875	46.7674	46.8461	46.9233	46.9996	47.0742	47.1479	47.2916
300.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	258.169	257.853	257.319	256.222	110.426	110.496	110.639	110.787	110.937	111.090	111.244	111.403	111.564	111.727	111.891	112.228
	s	0.43021	0.41016	0.39471	0.37873	0.17318	0.17300	0.17264	0.17229	0.17194	0.17160	0.17126	0.17092	0.17059	0.17027	0.16994	0.16931
	v	44.085	17.533	8.681	4.253	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.021	0.021	0.021	0.021	0.021
	d	0.0227	0.0570	0.1152	0.2351	46.0001	46.0458	46.1351	46.2223	46.3080	46.3919	46.4749	46.5556	46.6350	46.7131	46.7901	46.9401
310.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	261.992	261.685	261.168	260.107	115.580	115.647	115.782	115.921	116.064	116.209	116.358	116.509	116.665	116.822	116.982	117.309
	s	0.43521	0.41517	0.39974	0.38381	0.17992	0.17973	0.17937	0.17900	0.17864	0.17829	0.17794	0.17760	0.17726	0.17693	0.17660	0.17595
	v	44.673	17.771	8.803	4.317	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.021
	d	0.0224	0.0563	0.1136	0.2316	45.6008	45.6486	45.7428	45.8347	45.9249	46.0132	46.0997	46.1847	46.2676	46.3490	46.4292	46.5855
320.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	265.858	265.561	265.060	264.033	120.780	120.840	120.970	121.099	121.236	121.372	121.516	121.660	121.808	121.959	122.113	122.429
	s	0.44020	0.42017	0.40477	0.38888	0.18663	0.18644	0.18606	0.18569	0.18532	0.18495	0.18460	0.18425	0.18390	0.18356	0.18322	0.18256
	v	45.261	18.010	8.925	4.380	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0221	0.0555	0.1120	0.2283	45.1956	45.2464	45.3447	45.4423	45.5364	45.6298	45.7198	45.8088	45.8960	45.9815	46.0651	46.2283

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
330.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	269.766	269.478	268.993	268.	264.807	126.083	126.201	126.323	126.449	126.581	126.714	126.852	126.992	127.137	127.283	127.588
	s	0.44518	0.42516	0.40978	0.39393	0.37125	0.19312	0.19273	0.19234	0.19196	0.19159	0.19122	0.19087	0.19051	0.19016	0.18981	0.18914
	v	45.848	18.247	9.046	4.444	1.676	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0218	0.0548	0.1105	0.2250	0.5966	44.8372	44.9415	45.0441	45.1437	45.2409	45.3364	45.4294	45.5208	45.6102	45.6982	45.8683
340.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	273.717	273.439	272.968	272.007	268.926	131.375	131.480	131.594	131.710	131.831	131.956	132.085	132.221	132.357	132.497	132.788
	s	0.45015	0.43015	0.41478	0.39898	0.37643	0.19978	0.19937	0.19898	0.19858	0.19820	0.19782	0.19745	0.19709	0.19673	0.19637	0.19568
	v	46.434	18.485	9.167	4.507	1.705	0.023	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0215	0.0541	0.1091	0.2219	0.5865	44.4202	44.5319	44.6392	44.7446	44.8474	44.9478	45.0458	45.1409	45.2350	45.3268	45.5048
350.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	277.711	277.440	276.984	276.052	273.078	136.712	136.809	136.910	137.015	137.127	137.244	137.365	137.490	137.618	137.752	138.027
	s	0.45512	0.43512	0.41977	0.40400	0.38159	0.20641	0.20599	0.20558	0.20518	0.20478	0.20439	0.20401	0.20364	0.20326	0.20290	0.20219
	v	47.022	18.722	9.288	4.570	1.734	0.023	0.023	0.023	0.023	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0213	0.0534	0.1077	0.2188	0.5769	43.9969	44.1141	44.2283	44.3397	44.4481	44.5533	44.6563	44.7569	44.8557	44.9515	45.1378
360.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	281.747	281.484	281.041	280.137	277.264	142.102	142.184	142.272	142.369	142.468	142.575	142.687	142.802	142.922	143.049	143.309
	s	0.46007	0.44008	0.42475	0.40902	0.38673	0.21303	0.21259	0.21216	0.21175	0.21134	0.21094	0.21054	0.21016	0.20978	0.20941	0.20867
	v	47.607	18.959	9.409	4.632	1.762	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.022	0.022	0.022
	d	0.0210	0.0527	0.1063	0.2159	0.5676	43.5647	43.6897	43.8108	43.9280	44.0428	44.1537	44.2622	44.3681	44.4716	44.5717	44.7672
370.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	285.825	285.569	285.139	284.263	281.482	147.543	147.610	147.686	147.767	147.858	147.952	148.054	148.158	148.269	148.387	148.630
	s	0.46501	0.44504	0.42972	0.41402	0.39185	0.21963	0.21917	0.21873	0.21830	0.21787	0.21746	0.21705	0.21665	0.21626	0.21588	0.21513
	v	48.195	19.196	9.530	4.695	1.790	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	d	0.0207	0.0521	0.1049	0.2130	0.5588	43.1230	43.2561	43.3849	43.5098	43.6304	43.7481	43.8623	43.9741	44.0828	44.1880	44.3929
380.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	289.944	289.695	289.278	288.426	285.737	153.038	153.090	153.147	153.217	153.293	153.377	153.465	153.560	153.663	153.767	153.995
	s	0.46995	0.44998	0.43468	0.41901	0.39694	0.22621	0.22574	0.22527	0.22482	0.22439	0.22396	0.22354	0.22312	0.22272	0.22232	0.22155
	v	48.782	19.433	9.650	4.757	1.818	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	d	0.0205	0.0515	0.1036	0.2102	0.5502	42.6714	42.8128	42.9510	43.0831	43.2113	43.3356	43.4566	43.5740	43.6876	43.7996	44.0139
390.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	294.104	293.862	293.456	292.630	290.024	285.130	158.620	158.662	158.716	158.778	158.847	158.924	159.007	159.098	159.195	159.403
	s	0.47487	0.45491	0.43963	0.42399	0.40202	0.38282	0.23228	0.23180	0.23133	0.23088	0.23043	0.23000	0.22957	0.22916	0.22875	0.22796
	v	49.368	19.670	9.770	4.819	1.845	0.846	0.024	0.024	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	d	0.0203	0.0508	0.1024	0.2075	0.5420	1.1824	42.3604	42.5075	42.6482	42.7843	42.9162	43.0438	43.1680	43.2880	43.4048	43.6298
400.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	298.303	298.070	297.675	296.872	294.347	289.639	164.209	164.233	164.270	164.313	164.368	164.430	164.502	164.581	164.663	164.852
	s	0.47979	0.45984	0.44456	0.42895	0.40708	0.38809	0.23882	0.23832	0.23783	0.23735	0.23689	0.23644	0.23600	0.23557	0.23515	0.23433
	v	49.951	19.907	9.891	4.881	1.872	0.862	0.024	0.024	0.024	0.024	0.024	0.023	0.023	0.023	0.023	0.023
	d	0.0200	0.0502	0.1011	0.2049	0.5341	1.1596	41.8959	42.0523	42.2027	42.3486	42.4884	42.6241	42.7545	42.8812	43.0056	43.2417
410.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	302.545	302.317	301.933	301.152	298.705	294.168	169.857	169.859	169.874	169.900	169.940	169.987	170.043	170.106	170.179	170.345
	s	0.48469	0.46475	0.44949	0.43390	0.41212	0.39333	0.24536	0.24483	0.24431	0.24382	0.24334	0.24287	0.24241	0.24196	0.24153	0.24069
	v	50.539	20.143	10.010	4.943	1.900	0.879	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.023	0.023
	d	0.0198	0.0496	0.0999	0.2023	0.5264	1.1381	41.4132	41.5834	41.7457	41.9013	42.0500	42.1941	42.3332	42.4681	42.5982	42.8470

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
420.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	306.826	306.604	306.231	305.471	303.097	298.722	175.567	175.545	175.538	175.546	175.562	175.594	175.635	175.683	175.742	175.881
	s	0.48959	0.46965	0.45440	0.43884	0.41714	0.39854	0.25188	0.25133	0.25079	0.25027	0.24976	0.24928	0.24880	0.24834	0.24789	0.24701
	v	51.125	20.380	10.130	5.005	1.927	0.895	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	d	0.0196	0.0491	0.0987	0.1998	0.5190	1.1177	40.8920	41.0846	41.2636	41.4323	41.5946	41.7485	41.8968	42.0406	42.1786	42.4427
430.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	311.147	310.931	310.568	309.829	307.523	303.299	181.344	181.292	181.261	181.242	181.242	181.251	181.273	181.306	181.352	181.463
	s	0.49447	0.47454	0.45930	0.44376	0.42214	0.40371	0.25841	0.25782	0.25726	0.25671	0.25619	0.25567	0.25518	0.25469	0.25423	0.25332
	v	51.711	20.616	10.250	5.066	1.954	0.911	0.025	0.025	0.025	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	d	0.0193	0.0485	0.0976	0.1974	0.5119	1.0983	40.3512	40.5694	40.7665	40.9522	41.1259	41.2929	41.4521	41.6049	41.7513	42.0312
440.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	315.508	315.296	314.943	314.225	311.985	307.904	187.191	187.107	187.047	187.001	186.977	186.965	186.968	186.983	187.009	187.091
	s	0.49935	0.47942	0.46419	0.44868	0.42713	0.40886	0.26495	0.26432	0.26373	0.26315	0.26260	0.26206	0.26154	0.26104	0.26055	0.25961
	v	52.296	20.851	10.369	5.128	1.980	0.926	0.025	0.025	0.025	0.025	0.025	0.024	0.024	0.024	0.024	0.024
	d	0.0191	0.0480	0.0964	0.1950	0.5050	1.0797	39.7871	40.0343	40.2528	40.4556	40.6445	40.8243	40.9951	41.1587	41.3157	41.6124
450.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	319.908	319.702	319.357	318.658	316.481	312.533	193.117	192.991	192.896	192.823	192.771	192.735	192.715	192.710	192.719	192.768
	s	0.50421	0.48429	0.46907	0.45358	0.43210	0.41398	0.27150	0.27083	0.27019	0.26958	0.26900	0.26844	0.26789	0.26737	0.26686	0.26589
	v	52.883	21.088	10.489	5.189	2.007	0.942	0.026	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.024	0.024
	d	0.0189	0.0474	0.0953	0.1927	0.4983	1.0620	39.1978	39.4789	39.7217	39.9429	40.1489	40.3434	40.5273	40.7021	40.8692	41.1847
460.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	324.346	324.145	323.809	323.128	321.012	317.191	307.770	198.959	198.822	198.713	198.629	198.563	198.521	198.491	198.476	198.491
	s	0.50906	0.48915	0.47394	0.45846	0.43705	0.41907	0.39631	0.27735	0.27667	0.27602	0.27540	0.27481	0.27424	0.27369	0.27316	0.27215
	v	53.469	21.323	10.608	5.250	2.033	0.957	0.406	0.026	0.026	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	d	0.0187	0.0469	0.0943	0.1905	0.4918	1.0451	2.4607	38.8962	39.1673	39.4116	39.6364	39.8481	40.0454	40.2341	40.4140	40.7491
470.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.000	1200.
	h	328.823	328.627	328.300	327.636	325.577	321.875	312.887	205.009	204.826	204.674	204.554	204.456	204.384	204.330	204.292	204.266
	s	0.51390	0.49399	0.47880	0.46334	0.44199	0.42414	0.40184	0.28389	0.28316	0.28247	0.28181	0.28118	0.28058	0.28001	0.27945	0.27839
	v	54.052	21.559	10.728	5.311	2.060	0.972	0.417	0.026	0.026	0.026	0.026	0.025	0.025	0.025	0.025	0.025
	d	0.0185	0.0464	0.0932	0.1883	0.4855	1.0289	2.3968	38.2875	38.5893	38.8599	39.1066	39.3365	39.5507	39.7535	39.9459	40.3035
480.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	333.338	333.147	332.828	332.182	330.177	326.587	317.993	211.158	210.910	210.710	210.548	210.417	210.307	210.227	210.163	210.089
	s	0.51873	0.49883	0.48364	0.46820	0.44691	0.42918	0.40730	0.29047	0.28967	0.28893	0.28823	0.28756	0.28692	0.28631	0.28573	0.28462
	v	54.637	21.795	10.847	5.372	2.086	0.987	0.428	0.027	0.026	0.026	0.026	0.026	0.026	0.025	0.025	0.025
	d	0.0183	0.0459	0.0922	0.1861	0.4794	1.0134	2.3381	37.6452	37.9863	38.2861	38.5567	38.8068	39.0411	39.2585	39.4658	39.8494
490.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	337.891	337.705	337.393	336.763	334.812	331.328	323.090	217.418	217.099	216.839	216.624	216.446	216.302	216.187	216.091	215.967
	s	0.52356	0.50366	0.48847	0.47305	0.45182	0.43420	0.41270	0.29710	0.29622	0.29542	0.29466	0.29394	0.29327	0.29262	0.29200	0.29084
	v	55.224	22.030	10.966	5.433	2.112	1.002	0.438	0.027	0.027	0.027	0.026	0.026	0.026	0.026	0.026	0.025
	d	0.0181	0.0454	0.0912	0.1841	0.4735	0.9984	2.2840	36.9646	37.3494	37.6826	37.9836	38.2583	38.5123	38.7487	38.9728	39.3831
500.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	342.482	342.300	341.996	341.380	339.480	336.099	328.187	223.802	223.393	223.060	222.783	222.556	222.366	222.208	222.085	221.900
	s	0.52836	0.50847	0.49329	0.47789	0.45671	0.43919	0.41804	0.30379	0.30282	0.30193	0.30111	0.30034	0.29962	0.29893	0.29828	0.29706
	v	55.808	22.265	11.085	5.494	2.138	1.016	0.448	0.028	0.027	0.027	0.027	0.027	0.026	0.026	0.026	0.026
	d	0.0179	0.0449	0.0902	0.1820	0.4678	0.9840	2.2337	36.2399	36.6760	37.0506	37.3846	37.6867	37.9647	38.2234	38.4631	38.9050

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-1. Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
510.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	347.110	346.933	346.636	346.035	344.183	340.898	333.289	322.937	229.813	229.390	229.041	228.748	228.504	228.305	228.141	227.893
	s	0.53316	0.51327	0.49810	0.48271	0.46158	0.44417	0.42333	0.40608	0.30947	0.30849	0.30760	0.30676	0.30598	0.30525	0.30456	0.30327
	v	56.393	22.502	11.204	5.555	2.164	1.031	0.457	0.254	0.028	0.027	0.027	0.027	0.027	0.027	0.026	0.026
	d	0.0177	0.0444	0.0893	0.1800	0.4622	0.9702	2.1867	3.9327	35.9593	36.3826	36.7548	37.0904	37.3967	37.6775	37.9382	38.4135
520.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	351.774	351.601	351.311	350.725	348.920	345.727	338.396	328.725	236.396	235.850	235.399	235.035	234.730	234.476	234.266	233.944
	s	0.53795	0.51806	0.50290	0.48753	0.46644	0.44912	0.42857	0.41202	0.31623	0.31512	0.31412	0.31321	0.31237	0.31158	0.31084	0.30948
	v	56.976	22.736	11.322	5.615	2.190	1.045	0.467	0.264	0.028	0.028	0.028	0.027	0.027	0.027	0.027	0.026
	d	0.0176	0.0440	0.0883	0.1781	0.4567	0.9568	2.1428	3.7911	35.1851	35.6694	36.0921	36.4657	36.8028	37.1115	37.3955	37.9087
530.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	356.475	356.307	356.023	355.452	353.691	350.585	343.512	334.419	243.177	242.453	241.888	241.427	241.048	240.733	240.468	240.059
	s	0.54272	0.52284	0.50769	0.49233	0.47129	0.45406	0.43376	0.41780	0.32311	0.32183	0.32071	0.31970	0.31878	0.31794	0.31714	0.31569
	v	57.560	22.971	11.441	5.676	2.215	1.059	0.476	0.273	0.029	0.029	0.028	0.028	0.028	0.027	0.027	0.027
	d	0.0174	0.0435	0.0874	0.1762	0.4514	0.9439	2.1016	3.6674	34.3388	34.9075	35.3866	35.8067	36.1816	36.5207	36.8316	37.3884
540.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	361.214	361.049	360.772	360.213	358.494	355.473	348.643	340.046	250.215	249.258	248.520	247.944	247.468	247.078	246.752	246.244
	s	0.54748	0.52761	0.51246	0.49711	0.47612	0.45897	0.43892	0.42346	0.33019	0.32867	0.32738	0.32625	0.32524	0.32431	0.32346	0.32191
	v	58.147	23.207	11.560	5.736	2.241	1.074	0.485	0.281	0.030	0.029	0.029	0.028	0.028	0.028	0.028	0.027
	d	0.0172	0.0431	0.0865	0.1743	0.4463	0.9314	2.0625	3.5576	33.3995	34.0742	34.6324	35.1075	35.5283	35.9036	36.2451	36.8505
550.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	365.988	365.826	365.555	365.009	363.332	360.391	353.786	345.628	333.614	256.295	255.336	254.602	254.005	253.527	253.123	252.497
	s	0.55224	0.53236	0.51722	0.50189	0.48093	0.46387	0.44404	0.42901	0.41292	0.33567	0.33416	0.33288	0.33175	0.33073	0.32980	0.32813
	v	58.732	23.442	11.679	5.796	2.266	1.088	0.494	0.289	0.175	0.030	0.030	0.029	0.029	0.028	0.028	0.028
	d	0.0170	0.0427	0.0856	0.1725	0.4412	0.9194	2.0256	3.4587	5.7051	33.1594	33.8151	34.3616	34.8378	35.2557	35.6335	36.2951
560.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	370.798	370.639	370.375	369.841	368.204	365.338	358.946	351.175	340.367	263.694	262.397	261.430	260.686	260.085	259.589	258.836
	s	0.55698	0.53710	0.52197	0.50665	0.48573	0.46874	0.44913	0.43448	0.41958	0.34296	0.34112	0.33961	0.33833	0.33720	0.33617	0.33438
	v	59.318	23.676	11.798	5.857	2.292	1.102	0.502	0.297	0.185	0.031	0.030	0.030	0.029	0.029	0.029	0.028
	d	0.0169	0.0422	0.0848	0.1707	0.4363	0.9077	1.9906	3.3690	5.4051	32.1172	32.9136	33.5597	34.1016	34.5740	34.9940	35.7163
570.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	375.642	375.488	375.229	374.707	373.108	370.316	364.122	356.699	346.801	271.683	269.758	268.481	267.525	266.783	266.164	265.252
	s	0.56170	0.54184	0.52671	0.51140	0.49052	0.47360	0.45418	0.43987	0.42586	0.35076	0.34830	0.34649	0.34500	0.34373	0.34259	0.34064
	v	59.900	23.913	11.916	5.917	2.317	1.116	0.511	0.304	0.194	0.032	0.031	0.031	0.030	0.030	0.029	0.028
	d	0.0167	0.0418	0.0839	0.1690	0.4316	0.8964	1.9573	3.2869	5.1651	30.8711	31.9100	32.6821	33.3135	33.8475	34.3218	35.1170
580.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	380.522	380.370	380.119	379.608	378.047	375.324	369.317	362.211	353.041	380.623	277.610	275.812	274.568	273.622	272.873	271.753
	s	0.56642	0.54656	0.53144	0.51613	0.49529	0.47844	0.45920	0.44520	0.43189	0.52348	0.35589	0.35358	0.35181	0.35034	0.34908	0.34692
	v	60.484	24.146	12.034	5.977	2.343	1.129	0.519	0.311	0.201	0.162	0.033	0.032	0.031	0.030	0.030	0.029
	d	0.0165	0.0414	0.0831	0.1673	0.4269	0.8854	1.9257	3.2109	4.9635	6.1819	30.7442	31.7131	32.4593	33.0775	33.6086	34.4949
590.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	385.438	385.288	385.042	384.543	383.016	380.361	374.532	367.714	359.143	345.983	286.327	283.559	281.871	280.660	279.717	278.363
	s	0.57113	0.55126	0.53615	0.52086	0.50005	0.48326	0.46419	0.45047	0.43773	0.42221	0.36423	0.36099	0.35880	0.35708	0.35563	0.35325
	v	61.072	24.381	12.152	6.037	2.368	1.143	0.528	0.318	0.209	0.133	0.034	0.033	0.032	0.031	0.030	0.030
	d	0.0164	0.0410	0.0823	0.1656	0.4223	0.8748	1.8954	3.1404	4.7903	7.5175	29.3024	30.6096	31.5210	32.2446	32.8545	33.8410

P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
600.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	390.386	390.242	390.	389.512	388.020	385.429	379.768	373.212	365.154	353.726	297.304	291.967	289.533	287.919	286.741	285.081
	s	0.57582	0.55596	0.54085	0.52557	0.50479	0.48807	0.46915	0.45568	0.44343	0.42956	0.37464	0.36896	0.36607	0.36396	0.36229	0.35962
	v	61.652	24.617	12.271	6.098	2.393	1.157	0.536	0.325	0.216	0.143	0.037	0.034	0.033	0.032	0.031	0.030
	d	0.0162	0.0406	0.0815	0.1640	0.4179	0.8644	1.8663	3.0748	4.6376	7.0097	27.1487	29.3003	30.4706	31.3426	32.0444	33.1567
610.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	395.369	395.228	394.991	394.514	393.055	390.526	385.025	378.711	371.094	360.862	339.199	301.652	297.695	295.486	293.967	291.926
	s	0.58050	0.56064	0.54554	0.53027	0.50952	0.49285	0.47409	0.46084	0.44901	0.43626	0.41396	0.37806	0.37373	0.37107	0.36907	0.36605
	v	62.236	24.851	12.389	6.158	2.418	1.170	0.544	0.332	0.222	0.151	0.084	0.036	0.034	0.033	0.032	0.031
	d	0.0161	0.0402	0.0807	0.1624	0.4135	0.8544	1.8385	3.0135	4.5015	6.6313	11.9018	27.6046	29.2695	30.3471	31.1743	32.4363
620.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	400.388	400.250	400.016	399.549	398.122	395.653	390.301	384.215	376.985	367.651	352.375	314.898	306.689	303.458	301.449	298.910
	s	0.58517	0.56532	0.55021	0.53495	0.51424	0.49762	0.47900	0.46597	0.45449	0.44258	0.42623	0.39038	0.38210	0.37849	0.37603	0.37255
	v	62.823	25.087	12.507	6.218	2.443	1.184	0.552	0.338	0.228	0.158	0.101	0.041	0.036	0.034	0.033	0.032
	d	0.0159	0.0399	0.0800	0.1608	0.4093	0.8446	1.8119	2.9556	4.3787	6.3281	9.8590	24.6692	27.8198	29.2316	30.2289	31.6765
630.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	405.439	405.302	405.075	404.617	403.222	400.809	395.601	389.724	382.839	374.217	361.636	334.365	317.146	311.999	309.252	306.054
	s	0.58983	0.56997	0.55488	0.53963	0.51894	0.50238	0.48389	0.47105	0.45989	0.44863	0.43477	0.40833	0.39174	0.38636	0.38323	0.37914
	v	63.406	25.320	12.625	6.277	2.468	1.197	0.560	0.345	0.234	0.165	0.112	0.055	0.039	0.036	0.034	0.032
	d	0.0158	0.0395	0.0792	0.1593	0.4051	0.8351	1.7864	2.9012	4.2667	6.0745	8.9415	18.1707	25.9026	27.9512	29.1916	30.8728
640.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	410.522	410.389	410.166	409.719	408.352	405.995	400.926	395.242	388.664	380.635	369.706	350.504	329.692	321.345	317.465	313.382
	s	0.59447	0.57462	0.55953	0.54429	0.52363	0.50712	0.48875	0.47609	0.46521	0.45449	0.44214	0.42307	0.40320	0.39490	0.39073	0.38583
	v	63.989	25.555	12.743	6.337	2.493	1.211	0.568	0.351	0.240	0.171	0.120	0.073	0.043	0.038	0.036	0.033
	d	0.0156	0.0391	0.0785	0.1578	0.4011	0.8258	1.7616	2.8497	4.1642	5.8556	8.3311	13.7178	23.0540	26.4276	28.0400	30.0193
650.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	415.640	415.510	415.292	414.853	413.516	411.210	406.272	400.770	394.471	386.938	377.170	362.317	342.978	331.648	326.179	320.919
	s	0.59910	0.57926	0.56417	0.54893	0.52830	0.51184	0.49359	0.48109	0.47047	0.46020	0.44890	0.43377	0.41523	0.40423	0.39862	0.39265
	v	64.573	25.790	12.862	6.397	2.518	1.224	0.575	0.357	0.246	0.177	0.127	0.085	0.052	0.041	0.037	0.034
	d	0.0155	0.0388	0.0778	0.1563	0.3971	0.8168	1.7379	2.8009	4.0694	5.6642	7.8714	11.7209	19.4102	24.5468	26.7456	29.1120
660.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	420.790	420.663	420.448	420.019	418.709	416.456	411.642	406.310	400.268	393.159	384.274	371.931	355.302	342.559	335.432	328.687
	s	0.60372	0.58388	0.56879	0.55357	0.53296	0.51654	0.49841	0.48606	0.47567	0.46578	0.45527	0.44240	0.42628	0.41401	0.40692	0.39962
	v	65.158	26.025	12.979	6.457	2.543	1.238	0.583	0.363	0.251	0.182	0.133	0.094	0.061	0.045	0.040	0.036
	d	0.0153	0.0384	0.0770	0.1549	0.3932	0.8080	1.7150	2.7545	3.9810	5.4938	7.5010	10.5905	16.2840	22.2636	25.2755	28.1473
670.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	425.973	425.847	425.638	425.217	423.934	421.730	417.036	411.866	406.054	399.316	391.133	380.429	366.280	353.432	345.081	336.697
	s	0.60833	0.58849	0.57341	0.55819	0.53761	0.52123	0.50321	0.49100	0.48081	0.47125	0.46137	0.44995	0.43605	0.42368	0.41550	0.40674
	v	65.744	26.258	13.098	6.517	2.568	1.251	0.591	0.369	0.256	0.187	0.139	0.102	0.071	0.051	0.042	0.037
	d	0.0152	0.0381	0.0763	0.1534	0.3894	0.7994	1.6928	2.7101	3.8989	5.3406	7.1915	9.8237	14.1507	19.7957	23.6127	27.1238
680.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	431.188	431.064	430.859	430.446	429.190	427.033	422.453	417.436	411.839	405.429	397.818	388.280	376.097	363.861	354.841	344.942
	s	0.61293	0.59309	0.57801	0.56280	0.54224	0.52591	0.50798	0.49591	0.48591	0.47664	0.46726	0.45687	0.44470	0.43287	0.42410	0.41401
	v	66.328	26.493	13.215	6.576	2.593	1.264	0.598	0.375	0.262	0.192	0.144	0.108	0.079	0.057	0.046	0.038
	d	0.0151	0.0377	0.0757	0.1521	0.3857	0.7911	1.6714	2.6679	3.8217	5.2009	6.9262	9.2486	12.7194	17.5451	21.7973	26.0411

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic root

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
690.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	436.433	436.313	436.111	435.708	434.476	432.366	427.895	423.021	417.621	411.507	404.378	395.723	385.041	373.699	364.478	353.366
	s	0.61751	0.59767	0.58260	0.56740	0.54686	0.53056	0.51273	0.50079	0.49096	0.48195	0.47299	0.46337	0.45251	0.44147	0.43252	0.42137
	v	66.908	26.727	13.333	6.636	2.617	1.277	0.606	0.381	0.267	0.197	0.149	0.114	0.085	0.064	0.050	0.040
	d	0.0149	0.0374	0.0750	0.1507	0.3821	0.7829	1.6507	2.6275	3.7493	5.0730	6.6934	8.7894	11.7047	15.7323	19.9482	24.9042
700.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	441.713	441.593	441.396	440.999	439.792	437.727	433.361	428.622	423.405	417.555	410.842	402.894	393.352	382.965	373.859	361.901
	s	0.62208	0.60225	0.58717	0.57198	0.55146	0.53521	0.51747	0.50564	0.49597	0.48719	0.47859	0.46958	0.45971	0.44949	0.44064	0.42876
	v	67.497	26.961	13.451	6.696	2.642	1.290	0.613	0.386	0.272	0.202	0.154	0.119	0.091	0.070	0.055	0.042
	d	0.0148	0.0371	0.0743	0.1493	0.3785	0.7750	1.6307	2.5889	3.6811	4.9554	6.4867	8.4064	10.9419	14.3344	18.2227	23.7148
710.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	447.021	446.904	446.711	446.321	445.139	443.116	438.851	434.241	429.196	423.588	417.233	409.858	401.215	391.718	382.917	370.458
	s	0.62664	0.60681	0.59174	0.57655	0.55605	0.53984	0.52218	0.51046	0.50094	0.49237	0.48408	0.47557	0.46646	0.45701	0.44842	0.43611
	v	68.078	27.196	13.569	6.755	2.667	1.303	0.621	0.392	0.277	0.206	0.159	0.124	0.097	0.075	0.060	0.044
	d	0.0147	0.0368	0.0737	0.1480	0.3750	0.7672	1.6113	2.5518	3.6165	4.8458	6.3009	8.0803	10.3390	13.2559	16.7245	22.4871
720.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	452.361	452.248	452.058	451.676	450.516	448.533	444.367	439.878	434.993	429.604	423.566	416.676	408.749	400.041	391.657	378.970
	s	0.63119	0.61136	0.59629	0.58111	0.56063	0.54445	0.52688	0.51526	0.50588	0.49749	0.48947	0.48137	0.47288	0.46410	0.45586	0.44335
	v	68.661	27.431	13.687	6.815	2.692	1.316	0.628	0.397	0.281	0.211	0.163	0.128	0.102	0.081	0.065	0.047
	d	0.0146	0.0365	0.0731	0.1467	0.3715	0.7596	1.5924	2.5162	3.5551	4.7440	6.1325	7.7957	9.8450	12.4058	15.4696	21.2455
730.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	457.732	457.620	457.434	457.059	455.922	453.980	449.907	445.534	440.799	435.612	429.857	423.374	416.045	408.013	400.079	387.391
	s	0.63572	0.61589	0.60083	0.58565	0.56519	0.54904	0.53155	0.52004	0.51078	0.50256	0.49478	0.48702	0.47903	0.47082	0.46297	0.45046
	v	69.245	27.665	13.805	6.874	2.716	1.329	0.635	0.403	0.286	0.215	0.167	0.133	0.106	0.085	0.069	0.050
	d	0.0144	0.0361	0.0724	0.1455	0.3682	0.7522	1.5741	2.4819	3.4968	4.6486	5.9781	7.5449	9.4270	11.7179	14.4370	20.0270
740.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	463.134	463.024	462.840	462.472	461.357	459.456	455.471	451.211	446.616	441.615	436.111	429.987	423.153	415.708	408.222	395.693
	s	0.64024	0.62041	0.60535	0.59018	0.56974	0.55363	0.53621	0.52479	0.51565	0.50759	0.50001	0.49256	0.48498	0.47727	0.46979	0.45741
	v	69.831	27.900	13.922	6.934	2.741	1.343	0.643	0.408	0.291	0.219	0.171	0.137	0.110	0.090	0.074	0.053
	d	0.0143	0.0358	0.0718	0.1442	0.3649	0.7449	1.5563	2.4487	3.4411	4.5589	5.8364	7.3197	9.0674	11.1459	13.5827	18.8700
750.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	468.566	468.457	468.276	467.916	466.823	464.957	461.059	456.905	452.444	447.615	442.340	436.528	430.119	423.181	416.127	403.866
	s	0.64475	0.62492	0.60987	0.59470	0.57428	0.55819	0.54085	0.52952	0.52049	0.51257	0.50518	0.49799	0.49077	0.48347	0.47635	0.46420
	v	70.416	28.133	14.040	6.993	2.765	1.355	0.650	0.414	0.295	0.223	0.175	0.141	0.114	0.094	0.078	0.056
	d	0.0142	0.0355	0.0712	0.1430	0.3616	0.7378	1.5391	2.4169	3.3881	4.4746	5.7050	7.1163	8.7520	10.6600	12.8662	17.8009
760.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	474.025	473.920	473.744	473.389	472.314	470.487	466.672	462.618	458.283	453.616	448.549	443.017	436.971	430.470	423.818	411.897
	s	0.64924	0.62942	0.61437	0.59921	0.57880	0.56275	0.54547	0.53422	0.52530	0.51751	0.51030	0.50333	0.49641	0.48947	0.48268	0.47081
	v	70.995	28.367	14.158	7.053	2.790	1.368	0.657	0.419	0.300	0.228	0.179	0.144	0.118	0.098	0.082	0.059
	d	0.0141	0.0353	0.0706	0.1418	0.3585	0.7308	1.5223	2.3863	3.3374	4.3948	5.5827	6.9304	8.4719	10.2412	12.2590	16.8366
770.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	479.517	479.413	479.240	478.891	477.838	476.045	472.311	468.355	464.138	459.619	454.743	449.459	443.736	437.618	431.335	419.793
	s	0.65373	0.63391	0.61885	0.60370	0.58331	0.56729	0.55008	0.53890	0.53008	0.52241	0.51535	0.50859	0.50193	0.49531	0.48882	0.47726
	v	71.582	28.602	14.276	7.112	2.814	1.381	0.664	0.424	0.304	0.232	0.183	0.148	0.122	0.101	0.085	0.063
	d	0.0140	0.0350	0.0700	0.1406	0.3553	0.7240	1.5060	2.3564	3.2888	4.3193	5.4685	6.7602	8.2200	9.8731	11.7352	15.9769

P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-1, Thermodynamic Properties of Toluene at Even Increments of Temperature and Pressure

Temp.																
780.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	485.036	484.934	484.765	484.423	483.387	481.630	477.973	474.110	470.006	465.626	460.927	455.869	450.426	444.643	438.695	427.558
	s	0.65820	0.63838	0.62333	0.60818	0.58780	0.57181	0.55466	0.54357	0.53483	0.52728	0.52036	0.51378	0.50735	0.50100	0.49478	0.48355
	v	72.163	28.836	14.394	7.172	2.839	1.394	0.671	0.430	0.308	0.235	0.187	0.151	0.125	0.105	0.089	0.066
	d	0.0139	0.0347	0.0695	0.1394	0.3523	0.7173	1.4901	2.3276	3.2421	4.2476	5.3614	6.6026	7.9921	9.5474	11.2799	15.2153
790.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	490.585	490.487	490.318	489.983	488.967	487.242	483.661	479.884	475.889	471.641	467.105	462.253	457.063	451.579	445.930	435.199
	s	0.66266	0.64284	0.62779	0.61265	0.59229	0.57632	0.55923	0.54820	0.53956	0.53211	0.52533	0.51891	0.51268	0.50657	0.50060	0.48968
	v	72.748	29.071	14.510	7.231	2.863	1.407	0.678	0.435	0.313	0.239	0.190	0.155	0.128	0.108	0.092	0.069
	d	0.0137	0.0344	0.0689	0.1383	0.3493	0.7108	1.4745	2.3000	3.1973	4.1792	5.2603	6.4562	7.7834	9.2538	10.8773	14.5429
800.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	496.164	496.065	495.901	495.571	494.573	492.879	489.372	485.681	481.788	477.661	473.277	468.610	463.652	458.430	453.063	442.732
	s	0.66710	0.64729	0.63224	0.61710	0.59676	0.58081	0.56378	0.55282	0.54426	0.53691	0.53025	0.52398	0.51793	0.51203	0.50628	0.49569
	v	73.333	29.304	14.629	7.290	2.887	1.420	0.685	0.440	0.317	0.243	0.194	0.158	0.132	0.111	0.095	0.072
	d	0.0136	0.0341	0.0684	0.1372	0.3463	0.7044	1.4594	2.2730	3.1541	4.1143	5.1653	6.3204	7.5917	8.9894	10.5173	13.9453
810.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	501.769	501.672	501.511	501.188	500.207	498.547	495.108	491.499	487.703	483.695	479.451	474.958	470.203	465.222	460.104	450.163
	s	0.67154	0.65172	0.63668	0.62154	0.60121	0.58529	0.56832	0.55742	0.54893	0.54168	0.53513	0.52900	0.52311	0.51740	0.51185	0.50156
	v	73.915	29.538	14.746	7.350	2.912	1.432	0.692	0.445	0.321	0.247	0.197	0.161	0.135	0.114	0.098	0.075
	d	0.0135	0.0339	0.0678	0.1361	0.3434	0.6981	1.4447	2.2468	3.1126	4.0517	5.0749	6.1923	7.4144	8.7471	10.1939	13.4136
820.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	507.403	507.309	507.149	506.831	505.869	504.239	500.867	497.338	493.633	489.736	485.626	481.288	476.723	471.960	467.068	457.501
	s	0.67596	0.65614	0.64110	0.62597	0.60565	0.58976	0.57284	0.56201	0.55359	0.54642	0.53997	0.53396	0.52823	0.52269	0.51731	0.50732
	v	74.497	29.773	14.863	7.409	2.936	1.445	0.699	0.450	0.325	0.250	0.200	0.165	0.138	0.117	0.101	0.077
	d	0.0134	0.0336	0.0673	0.1350	0.3406	0.6920	1.4303	2.2214	3.0726	3.9922	4.9893	6.0727	7.2499	8.5249	9.9006	12.9381
830.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	513.065	512.972	512.816	512.503	511.558	509.956	506.651	503.199	499.583	495.790	491.802	487.612	483.221	478.651	473.970	464.758
	s	0.68036	0.66055	0.64551	0.63038	0.61008	0.59421	0.57734	0.56657	0.55822	0.55113	0.54478	0.53889	0.53329	0.52790	0.52268	0.51297
	v	75.082	30.006	14.981	7.468	2.961	1.458	0.706	0.455	0.330	0.254	0.204	0.168	0.141	0.120	0.104	0.080
	d	0.0133	0.0333	0.0668	0.1339	0.3378	0.6860	1.4163	2.1966	3.0338	3.9349	4.9079	5.9597	7.0959	8.3203	9.6325	12.5096
840.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	518.755	518.663	518.510	518.203	517.274	515.701	512.458	509.080	505.550	501.853	497.983	493.932	489.700	485.310	480.816	471.948
	s	0.68476	0.66495	0.64991	0.63479	0.61450	0.59865	0.58182	0.57111	0.56283	0.55581	0.54955	0.54377	0.53829	0.53304	0.52797	0.51852
	v	75.666	30.240	15.098	7.527	2.985	1.471	0.713	0.460	0.334	0.258	0.207	0.171	0.144	0.123	0.107	0.083
	d	0.0132	0.0331	0.0662	0.1328	0.3350	0.6800	1.4026	2.1727	2.9964	3.8803	4.8304	5.8527	6.9518	8.1299	9.3867	12.1204
850.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	524.472	524.382	524.232	523.929	523.017	521.472	518.291	514.984	511.534	507.932	504.172	500.245	496.158	491.936	487.618	479.069
	s	0.68914	0.66933	0.65430	0.63918	0.61890	0.60307	0.58630	0.57564	0.56741	0.56047	0.55430	0.54861	0.54324	0.53812	0.53319	0.52398
	v	76.248	30.475	15.216	7.587	3.009	1.483	0.720	0.465	0.338	0.261	0.210	0.174	0.147	0.126	0.109	0.085
	d	0.0131	0.0328	0.0657	0.1318	0.3323	0.6742	1.3891	2.1493	2.9602	3.8275	4.7562	5.7518	6.8172	7.9531	9.1595	11.7670

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.										
60.	P	13.816	4799.647							
	h	-0.005	11.270							
	s	0.00	-0.01							
	v	0.018	0.018							
	d	54.4921	55.8204							
70.	P	3584.117								
	h	12.364								
	s	0.00								
	v	0.018								
	d	55.2268								
80.	P	2423.009								
	h	13.693								
	s	0.01								
	v	0.018								
	d	54.6061								
90.	P	1315.709								
	h	15.260								
	s	0.02								
	v	0.019								
	d	53.9548								
100.	P	270.524	4885.912							
	h	17.093	27.754							
	s	0.03	0.02							
	v	0.019	0.018							
	d	53.2710	54.7295							
110.	P	0.961		3619.594						
	h	194.423	Phase	28.976						
	s	0.35	Change	0.03						
	v	68.723		0.018						
	d	0.0146		54.0780						
120.	P	1.214		2417.780						
	h	197.301	Phase	30.462						
	s	0.35	Change	0.04						
	v	55.322		0.019						
	d	0.0181		53.3944						
130.	P	0.970	1.532		1280.368					
	h	200.330	200.220	Phase	32.222					
	s	0.36	0.35	Change	0.05					
	v	70.546	44.533		0.019					
	d	0.0142	0.0225		52.6735					
140.	P	1.225	1.933		219.114	4602.413				
	h	203.311	203.177	Phase	34.294	44.145				
	s	0.36	0.35	Change	0.06	0.05				
	v	56.754	35.850		0.019	0.019				
	d	0.0176	0.0279		51.9134	53.5204				
Temp.										
150.	P	0.978	1.546	2.437		3305.133				
	h	206.436	206.333	206.171	Phase	45.543				
	s	0.37	0.36	0.35	Change	0.06				
	v	72.362	45.661	28.864		0.019				
	d	0.0138	0.0219	0.0346		52.7986				
160.	P	1.235	1.951	3.069		2087.313				
	h	209.518	209.394	209.198	Phase	47.254				
	s	0.37	0.36	0.35	Change	0.07				
	v	58.188	36.738	23.248		0.019				
	d	0.0172	0.0272	0.0430		52.0383				
170.	P	0.985	1.559	2.459	3.862		951.861			
	h	212.736	212.640	212.490	212.254	Phase	49.301			
	s	0.38	0.37	0.36	0.35	Change	0.08			
	v	74.180	46.791	29.565	18.730		0.020			
	d	0.0135	0.0214	0.0338	0.0534		51.2335			
180.	P	1.245	1.967	3.098	4.854		3979.953			
	h	215.918	215.802	215.620	215.335	Phase	60.487			
	s	0.38	0.37	0.36	0.35	Change	0.08			
	v	59.627	37.636	23.800	15.098		0.019			
	d	0.0168	0.0266	0.0420	0.0662		52.1603			
190.	P	0.992	1.571	2.480	3.899	6.092		2687.684		
	h	219.230	219.141	219.	218.780	218.435	Phase	62.167		
	s	0.39	0.38	0.37	0.36	0.35	Change	0.09		
	v	76.025	47.941	30.278	19.168	12.179		0.019		
	d	0.0132	0.0209	0.0330	0.0522	0.0821		51.3538		
200.	P	1.253	1.982	3.124	4.901	7.632		1490.076		
	h	222.510	222.403	222.232	221.964	221.549	Phase	64.222		
	s	0.39	0.38	0.37	0.36	0.35	Change	0.10		
	v	61.100	38.552	24.367	15.444	9.832		0.020		
	d	0.0164	0.0259	0.0410	0.0648	0.1017		50.4986		
210.	P	0.999	1.581	2.498	3.931	6.152	9.543		404.283	4441.337
	h	225.914	225.831	225.699	225.493	225.170	224.669	Phase	66.710	75.279
	s	0.40	0.39	0.38	0.37	0.36	0.35	Change	0.11	0.10
	v	77.910	49.116	31.007	19.618	12.452	7.945		0.020	0.019
	d	0.0128	0.0204	0.0323	0.0510	0.0803	0.1259		49.5925	51.4694
220.	P	1.260	1.994	3.146	4.942	7.710	11.904		3089.813	
	h	229.291	229.190	229.030	228.780	228.390	227.788	Phase	76.970	
	s	0.40	0.39	0.38	0.37	0.36	0.35	Change	0.11	
	v	62.611	39.491	24.950	15.802	10.048	6.428		0.020	
	d	0.0160	0.0253	0.0401	0.0633	0.0995	0.1556		50.6119	
230.	P	1.004	1.590	2.513	3.959	6.204	9.645		1853.771	
	h	232.785	232.707	232.585	232.391	232.088	231.617	Phase	79.098	
	s	0.41	0.40	0.39	0.38	0.37	0.36	Change	0.12	
	v	79.851	50.327	31.761	20.082	12.738	8.116		0.020	
	d	0.0125	0.0199	0.0315	0.0498	0.0785	0.1232		49.7040	

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.											
240.	P	1.266	2.004	3.165	4.976	7.777	12.038		734.579	4698.054	
	h	236.257	236.163	236.014	235.779	235.412	234.844	Phase	81.691	89.933	
	s	0.41	0.40	0.39	0.38	0.37	0.36	Change	0.13	0.12	
	v	64.168	40.465	25.553	16.175	10.275	6.563		0.021	0.020	
	d	0.0156	0.0247	0.0391	0.0618	0.0973	0.1524		48.7358	50.7173	
250.	P	1.008	1.597	2.525	3.982	6.248	9.731	14.987		3310.845	
	h	239.841	239.768	239.653	239.473	239.188	238.745	238.062	Phase	91.700	
	s	0.42	0.41	0.40	0.39	0.38	0.37	0.36	Change	0.13	
	v	81.856	51.584	32.544	20.569	13.036	8.297	5.314		0.020	
	d	0.0122	0.0194	0.0307	0.0486	0.0767	0.1205	0.1882		49.8058	
260.	P	1.271	2.012	3.179	5.004	7.831	12.150	18.602		2047.262	
	h	243.407	243.318	243.179	242.959	242.613	242.078	241.260	Phase	93.943	
	s	0.42	0.41	0.40	0.39	0.38	0.37	0.36	Change	0.14	
	v	65.792	41.479	26.185	16.565	10.514	6.707	4.310		0.020	
	d	0.0152	0.0241	0.0382	0.0604	0.0951	0.1491	0.2320		48.8357	
270.	P	1.010	1.602	2.534	3.998	6.281	9.800	15.133	23.011		918.386	4766.150
	h	247.080	247.012	246.903	246.734	246.466	246.049	245.405	244.426	Phase	96.716	104.484
	s	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	Change	0.15	0.14
	v	83.959	52.897	33.363	21.078	13.349	8.487	5.429	3.503		0.021	0.020
	d	0.0119	0.0189	0.0300	0.0474	0.0749	0.1178	0.1842	0.2855		47.7998	49.8967
280.	P	1.273	2.017	3.189	5.024	7.873	12.239	18.796	28.352		3359.804	
	h	250.737	250.654	250.523	250.315	249.991	249.487	248.714	247.546	Phase	106.383	
	s	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	Change	0.15	
	v	67.491	42.540	26.847	16.974	10.765	6.859	4.401	2.852		0.020	
	d	0.0148	0.0235	0.0372	0.0589	0.0929	0.1458	0.2272	0.3506		48.9232	
290.	P	1.012	1.604	2.539	4.009	6.304	9.852	15.251	23.272		2093.313	
	h	254.497	254.433	254.332	254.172	253.921	253.528	252.920	251.994	Phase	108.821	
	s	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	Change	0.16	
	v	86.157	54.275	34.223	21.613	13.680	8.690	5.550	3.574		0.021	
	d	0.0116	0.0184	0.0292	0.0463	0.0731	0.1151	0.1802	0.2798		47.8851	
300.	P	1.274	2.019	3.194	5.035	7.901	12.305	18.952	28.703		981.914	4665.383
	h	258.246	258.168	258.044	257.849	257.545	257.069	256.339	255.231	Phase	111.861	118.987
	s	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	Change	0.17	0.16
	v	69.284	43.661	27.545	17.409	11.033	7.022	4.498	2.909		0.021	0.020
	d	0.0144	0.0229	0.0363	0.0574	0.0906	0.1424	0.2223	0.3438		46.7766	48.9982
310.	P	1.012	1.604	2.540	4.013	6.317	9.886	15.337	23.479	35.252		3263.539
	h	262.092	262.032	261.937	261.787	261.551	261.180	260.606	259.729	258.411	Phase	121.096
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	Change	0.17
	v	88.467	55.732	35.136	22.180	14.033	8.906	5.681	3.652	2.373		0.021
	d	0.0113	0.0179	0.0285	0.0451	0.0713	0.1123	0.1760	0.2738	0.4215		47.9563
320.	P	1.273	2.018	3.193	5.038	7.915	12.347	19.065	28.986	43.086		2018.898
	h	265.929	265.856	265.740	265.557	265.269	264.821	264.131	263.080	261.519	Phase	123.814
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	Change	0.18
	v	71.177	44.850	28.288	17.870	11.318	7.197	4.603	2.970	1.941		0.021
	d	0.0140	0.0223	0.0354	0.0560	0.0884	0.1389	0.2172	0.3367	0.5153		46.8425

T in F. P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2. Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.													
330.	P	1.010	1.602	2.537	4.011	6.318	9.901	15.391	23.632	35.638	52.372		945.154
	h	269.861	269.805	269.715	269.574	269.351	269.003	268.462	267.631	266.379	264.538	Phase	127.203
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	Change	0.19
	v	90.953	57.280	36.104	22.784	14.407	9.138	5.822	3.736	2.422	1.592		0.022
	d	0.0110	0.0175	0.0277	0.0439	0.0694	0.1094	0.1717	0.2677	0.4129	0.6281		45.6500
330.	P	4420.680											
	h	133.515											
	s	0.18											
	v	0.021											
	d	48.0128											
340.	P	1.270	2.014	3.188	5.033	7.914	12.366	19.138	29.197	43.616		3048.741	
	h	273.785	273.717	273.608	273.436	273.165	272.743	272.090	271.095	269.608	Phase	135.923	
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	Change	0.19	
	v	73.190	46.112	29.076	18.363	11.623	7.384	4.717	3.038	1.979		0.021	
	d	0.0137	0.0217	0.0344	0.0545	0.0860	0.1354	0.2120	0.3292	0.5052		46.8945	
350.	P	1.007	1.597	2.530	4.002	6.309	9.898	15.414	23.731	35.932	53.104		1853.724
	h	277.800	277.748	277.663	277.531	277.322	276.994	276.483	275.697	274.509	272.752	Phase	139.016
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	Change	0.20
	v	93.573	58.924	37.134	23.428	14.809	9.386	5.974	3.827	2.475	1.622		0.022
	d	0.0107	0.0170	0.0269	0.0427	0.0675	0.1065	0.1674	0.2613	0.4040	0.6163		45.6988
360.	P	1.265	2.006	3.177	5.019	7.899	12.359	19.168	29.335	44.027	64.276		840.565	4062.685
	h	281.812	281.747	281.644	281.482	281.228	280.830	280.213	279.271	277.857	275.793	Phase	142.849	148.163
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	Change	0.21	0.20
	v	75.341	47.458	29.920	18.888	11.950	7.586	4.840	3.111	2.022	1.334		0.023	0.021
	d	0.0133	0.0211	0.0334	0.0529	0.0837	0.1318	0.2066	0.3214	0.4945	0.7494		44.4107	46.9309
370.	P	1.002	1.589	2.519	3.986	6.288	9.875	15.404	23.777	36.130	53.681	77.296		2746.350
	h	285.909	285.860	285.781	285.655	285.459	285.150	284.668	283.925	282.798	281.123	278.712	Phase	150.965
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	Change	0.21
	v	96.374	60.687	38.236	24.117	15.237	9.652	6.138	3.927	2.534	1.656	1.101		0.022
	d	0.0104	0.0165	0.0262	0.0415	0.0656	0.1036	0.1629	0.2547	0.3946	0.6037	0.9080		45.7274
380.	P	1.258	1.995	3.160	4.995	7.868	12.327	19.156	29.402	44.319	65.087	92.250		1625.139
	h	290.005	289.944	289.848	289.695	289.456	289.081	288.499	287.606	286.263	284.292	281.496	Phase	154.535
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	Change	0.22
	v	77.637	48.900	30.821	19.452	12.301	7.803	4.973	3.191	2.069	1.361	0.913		0.023
	d	0.0129	0.0204	0.0324	0.0514	0.0813	0.1282	0.2011	0.3133	0.4833	0.7346	1.0954		44.4383
390.	P	0.995	1.579	2.503	3.962	6.254	9.833	15.360	23.765	36.236	54.103	78.433		697.560	3623.966
	h	294.184	294.137	294.062	293.945	293.760	293.470	293.016	292.314	291.246	289.651	287.342	Phase	158.923	163.041
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	Change	0.23	0.22
	v	99.375	62.565	39.417	24.858	15.698	9.939	6.315	4.035	2.599	1.694	1.122		0.023	0.022
	d	0.0101	0.0160	0.0254	0.0402	0.0637	0.1006	0.1584	0.2479	0.3847	0.5902	0.8910		43.0403	45.7411
400.	P	1.248	1.981	3.138	4.962	7.822	12.269	19.102	29.398	44.486	65.702	93.830		2391.111
	h	298.363	298.306	298.215	298.073	297.847	297.494	296.945	296.100	294.825	292.945	290.261	Phase	166.347
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	Change	0.23
	v	80.097	50.446	31.792	20.059	12.679	8.037	5.117	3.279	2.122	1.391	0.929		0.023
	d	0.0125	0.0198	0.0315	0.0499	0.0789	0.1244	0.1954	0.3050	0.4714	0.7187	1.0760		44.4425

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.															
410.	P	0.986	1.566	2.483	3.931	6.209	9.771	15.285	23.698	36.251	54.369	79.320	111.459		1368.009	4478.394
	h	302.622	302.578	302.508	302.398	302.224	301.950	301.522	300.860	299.848	298.333	296.126	293.023	Phase	170.501	175.219
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	Change	0.24	0.23
	v	102.601	64.593	40.687	25.653	16.196	10.248	6.506	4.152	2.670	1.736	1.146	0.772		0.023	0.022
	d	0.0097	0.0155	0.0246	0.0390	0.0617	0.0976	0.1537	0.2408	0.3745	0.5760	0.8724	1.2948		43.0464	45.7377
420.	P	1.237	1.962	3.110	4.920	7.761	12.188	19.005	29.322	44.534	66.115	95.134	131.320		552.310	3140.097
	h	306.882	306.829	306.744	306.610	306.398	306.065	305.548	304.751	303.541	301.749	299.175	295.616	Phase	175.552	178.278
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	Change	0.25	0.24
	v	82.748	52.108	32.833	20.713	13.086	8.290	5.273	3.375	2.179	1.425	0.948	0.645		0.024	0.023
	d	0.0121	0.0192	0.0305	0.0483	0.0764	0.1206	0.1896	0.2963	0.4589	0.7018	1.0550	1.5511		41.5184	44.4276
430.	P	0.976	1.550	2.458	3.893	6.152	9.689	15.177	23.576	36.170	54.480	79.952	113.244	153.349		2020.465
	h	311.221	311.180	311.115	311.011	310.847	310.589	310.187	309.562	308.605	307.165	305.059	302.079	298.023	Phase	182.206
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	Change	0.25
	v	106.071	66.777	42.057	26.510	16.732	10.582	6.714	4.280	2.748	1.783	1.173	0.787	0.541		0.023
	d	0.0094	0.0150	0.0238	0.0377	0.0598	0.0945	0.1489	0.2337	0.3639	0.5610	0.8523	1.2702	1.8495		43.0206
440.	P	1.223	1.941	3.076	4.869	7.685	12.079	18.865	29.174	44.460	66.334	96.085	133.811		1116.261	3865.976
	h	315.562	315.513	315.433	315.306	315.106	314.794	314.307	313.554	312.408	310.705	308.241	304.813	Phase	187.051	190.309
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	Change	0.26	0.25
	v	85.604	53.904	33.961	21.416	13.526	8.565	5.443	3.479	2.242	1.462	0.969	0.656		0.024	0.023
	d	0.0117	0.0186	0.0294	0.0467	0.0739	0.1168	0.1837	0.2875	0.4460	0.6839	1.0316	1.5235		41.4909	44.3931
450.	P	0.964	1.531	2.428	3.848	6.083	9.588	15.036	23.402	35.998	54.435	80.335	114.678	156.774		
	h	319.978	319.940	319.878	319.781	319.628	319.386	319.006	318.417	317.512	316.148	314.140	311.280	307.365		
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40		
	v	109.810	69.128	43.533	27.435	17.313	10.944	6.939	4.418	2.833	1.834	1.203	0.804	0.550		
	d	0.0091	0.0145	0.0230	0.0364	0.0578	0.0914	0.1441	0.2263	0.3530	0.5453	0.8310	1.2436	1.8190		
460.	P	1.207	1.915	3.037	4.808	7.594	11.947	18.685	28.958	44.271	66.351	96.724	135.819	182.025		1662.793	4564.670
	h	324.399	324.352	324.276	324.158	323.971	323.677	323.218	322.508	321.424	319.806	317.453	314.159	309.721	Phase	198.679	202.424
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	Change	0.27	0.26
	v	88.689	55.840	35.174	22.178	14.003	8.862	5.627	3.592	2.311	1.504	0.993	0.670	0.463		0.024	0.023
	d	0.0113	0.0179	0.0284	0.0451	0.0714	0.1128	0.1777	0.2784	0.4327	0.6650	1.0066	1.4926	2.1614		41.4362	44.3409
470.	P	0.950	1.509	2.395	3.795	6.003	9.468	14.865	23.173	35.736	54.242	80.467	115.684	159.614	209.334		898.854
	h	328.891	328.855	328.797	328.705	328.562	328.335	327.978	327.423	326.570	325.276	323.366	320.629	316.855	311.877	Phase	204.327
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	Change	0.28
	v	113.858	71.664	45.127	28.435	17.939	11.336	7.182	4.569	2.925	1.890	1.237	0.823	0.560	0.391		0.025
	d	0.0088	0.0140	0.0222	0.0352	0.0557	0.0882	0.1392	0.2188	0.3418	0.5292	0.8086	1.2144	1.7843	2.5549		39.7524
470.	P	3261.372															
	h	205.939															
	s	0.27															
	v	0.023															
	d	42.9085															
480.	P	1.188	1.886	2.992	4.739	7.488	11.791	18.464	28.672	43.963	66.175	97.039	137.342	185.957		358.808	2190.705
	h	333.390	333.346	333.275	333.164	332.989	332.713	332.281	331.611	330.588	329.052	326.810	323.649	319.362	Phase	211.008	210.418
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	Change	0.29	0.28
	v	92.025	57.933	36.489	23.002	14.520	9.184	5.828	3.716	2.387	1.549	1.021	0.685	0.471		0.026	0.024
	d	0.0109	0.0173	0.0274	0.0435	0.0689	0.1089	0.1716	0.2691	0.4190	0.6455	0.9799	1.4589	2.1226		37.8510	41.3594

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.																
490.	P	0.935	1.485	2.356	3.736	5.912	9.330	14.661	22.891	35.387	53.897	80.352	116.294	161.865	214.684	1354.671
	h	337.957	337.923	337.870	337.783	337.648	337.435	337.101	336.579	335.773	334.550	332.735	330.119	326.490	321.664	Phase 215.918
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	Change 0.29
	v	118.224	74.412	46.857	29.518	18.618	11.760	7.448	4.734	3.027	1.952	1.274	0.845	0.573	0.398	0.025
	d	0.0085	0.0134	0.0213	0.0339	0.0537	0.0850	0.1343	0.2112	0.3304	0.5124	0.7851	1.1832	1.7458	2.5129	39.6739
490.	P	3841.761														
	h	217.936														
	s	0.28														
	v	0.023														
	d	42.8210														
500.	P	1.1[illegible]	1.654	2.941	4.660	7.368	11.610	18.204	28.320	43.545	65.808	97.039	138.386	189.194	245.494	
	h	3[illegible].532	342.490	342.425	342.321	342.156	341.897	341.492	340.861	339.897	338.442	336.308	333.280	329.144	323.755	
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	
	v	95.630	60.200	37.916	23.896	15.079	9.534	6.046	3.851	2.470	1.600	1.051	0.703	0.481	0.338	
	d	0.0105	0.0166	0.0264	0.0418	0.0663	0.1049	0.1654	0.2597	0.4049	0.6251	0.9518	1.4226	2.0795	2.9600	
510.	P	0.918	1.458	2.314	3.669	5.809	9.173	14.430	22.561	34.951	53.405	79.989	116.509	163.521	219.201	277.990
	h	347.173	347.141	347.091	347.010	346.884	346.684	346.371	345.880	345.121	343.967	342.244	339.750	336.265	331.597	325.635
	s	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41
	v	122.964	77.389	48.723	30.694	19.354	12.222	7.735	4.913	3.137	2.019	1.315	0.869	0.587	0.406	0.288
	d	0.0081	0.0129	0.0205	0.0326	0.0517	0.0818	0.1293	0.2035	0.3187	0.4952	0.7606	1.1501	1.7040	2.4650	3.4680
520.	P	1.145	1.819	2.886	4.573	7.234	11.408	17.906	27.905	43.015	65.253	96.735	138.981	191.701	251.650	311.696
	h	351.823	351.785	351.723	351.626	351.472	351.229	350.848	350.256	349.346	347.971	345.944	343.044	339.066	333.840	327.293
	s	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41
	v	99.587	62.661	39.457	24.865	15.687	9.913	6.283	3.998	2.560	1.655	1.084	0.722	0.492	0.344	0.247
	d	0.0100	0.0160	0.0253	0.0402	0.0637	0.1009	0.1592	0.2501	0.3906	0.6042	0.9226	1.3845	2.0320	2.9074	4.0430
530.	P	0.899	1.429	2.268	3.597	5.696	9.	14.168	22.184	34.436	52.777	79.388	116.333	164.578	222.852	286.196 345.886
	h	356.537	356.508	356.461	356.387	356.267	356.080	355.785	355.325	354.613	353.523	351.894	349.517	346.178	341.671	335.871 328.762
	s	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42 0.41
	v	128.100	80.621	50.754	31.971	20.154	12.723	8.049	5.108	3.258	2.094	1.360	0.897	0.603	0.415	0.293 0.213
	d	0.0078	0.0124	0.0197	0.0313	0.0496	0.0786	0.1242	0.1958	0.3069	0.4776	0.7353	1.1154	1.6591	2.4114	3.4113 4.6846
530.	P		668.582	2207.138	4917.652											
	h	Phase	241.564	239.435	242.159											
	s	Change	0.32	0.31	0.30											
	v		0.028	0.025	0.023											
	d		35.6795	39.4268	42.5889											
540.	P	1.121	1.780	2.825	4.479	7.087	11.184	17.573	27.429	42.382	64.517	96.122	139.043	193.468	256.789	322.369
	h	361.261	361.226	361.169	361.077	360.933	360.706	360.348	359.793	358.938	357.638	355.715	352.951	349.129	344.070	337.690 Phase
	s	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42 Change
	v	103.826	65.329	41.135	25.916	16.347	10.327	6.540	4.159	2.660	1.716	1.121	0.744	0.505	0.351	0.251
	d	0.0096	0.0153	0.0243	0.0386	0.0612	0.0968	0.1529	0.2405	0.3760	0.5828	0.8922	1.3435	1.9803	2.8476	3.9816
540.	P	411.571	1480.215	3627.784												
	h	250.085	245.776	246.200												
	s	0.33	0.32	0.31												
	v	0.030	0.027	0.024												
	d	33.4868	37.5703	40.9888												

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.																
550.	P	1.397	2.218	3.518	5.573	8.810	13.881	21.759	33.842	52.012	78.556	115.775	165.071	225.635	293.236	359.665
	h	366.020	365.975	365.906	365.796	365.620	365.345	364.913	364.243	363.218	361.677	359.419	356.224	351.884	346.252	339.298
	s	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	84.133	52.958	33.355	21.026	13.268	8.390	5.321	3.390	2.175	1.410	0.927	0.620	0.425	0.299	0.216
	d	0.0119	0.0189	0.0300	0.0476	0.0754	0.1192	0.1879	0.2950	0.4597	0.7093	1.0792	1.6119	2.3530	3.3461	4.6230
560.	P	1.095	1.739	2.760	4.377	6.928	10.939	17.204	26.894	41.651	63.610	95.222	138.619	194.501	260.903	331.759	397.490
	h	370.845	370.811	370.757	370.672	370.537	370.325	369.991	369.470	368.665	367.443	365.620	362.988	359.326	354.438	348.228	340.715
	s	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	108.431	68.226	42.957	27.061	17.065	10.777	6.822	4.334	2.768	1.783	1.161	0.769	0.519	0.359	0.256	0.187
	d	0.0092	0.0147	0.0233	0.0370	0.0586	0.0928	0.1466	0.2307	0.3612	0.5609	0.8610	1.3007	1.9250	2.7817	3.9105	5.3375
560.	P		672.102	1821.641	4053.261											
	h	Phase	261.675	257.611	258.287											
	s	Change	0.34	0.33	0.32											
	v		0.030	0.027	0.024											
	d		33.3907	37.3948	40.8221											
570.	P	1.363	2.164	3.433	5.440	8.604	13.567	21.293	33.172	51.118	77.507	114.841	164.921	227.502	299.064	371.969	435.448
	h	375.675	375.634	375.569	375.465	375.302	375.043	374.640	374.011	373.047	371.593	369.452	366.402	362.233	356.779	349.986	341.934
	s	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	87.947	55.360	34.864	21.970	13.862	8.761	5.553	3.535	2.265	1.465	0.960	0.640	0.437	0.306	0.220	0.163
	d	0.0114	0.0181	0.0287	0.0455	0.0721	0.1141	0.1801	0.2829	0.4416	0.6827	1.0418	1.5617	2.2895	3.2723	4.5477	6.1324
570.	P		526.573	1272.628	2970.835											
	h	Phase	271.055	264.986	263.345											
	s	Change	0.35	0.34	0.33											
	v		0.032	0.028	0.026											
	d		31.1929	35.3733	39.0775											
580.	P	1.067	1.695	2.691	4.267	6.757	10.676	16.805	26.306	40.824	62.539	94.036	137.736	194.808	263.940	339.772	413.236
	h	380.570	380.538	380.487	380.408	380.282	380.084	379.771	379.284	378.530	377.377	375.656	373.155	369.652	364.941	358.907	351.548
	s	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43
	v	113.451	71.387	44.939	28.308	17.847	11.268	7.129	4.526	2.887	1.856	1.206	0.796	0.536	0.369	0.261	0.190
	d	0.0088	0.0140	0.0223	0.0353	0.0560	0.0888	0.1403	0.2210	0.3463	0.5387	0.8289	1.2563	1.8667	2.7099	3.8299	5.2593
580.	P	473.036		925.047	2143.234	4449.561										
	h	342.995	Phase	273.416	269.553	270.443										
	s	0.42	Change	0.35	0.34	0.33										
	v	0.143		0.030	0.027	0.025										
	d	7.0071		33.2182	37.1894	40.6334										
590.	P	1.327	2.107	3.343	5.299	8.385	13.230	20.785	32.437	50.105	76.245	113.545	164.187	228.485	303.657	382.610	455.107
	h	385.471	385.431	385.371	385.275	385.122	384.881	384.504	383.916	383.011	381.642	379.616	376.711	372.711	367.438	360.824	352.926
	s	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43
	v	92.105	57.968	36.502	23.	14.508	9.166	5.807	3.693	2.363	1.525	0.997	0.663	0.450	0.313	0.224	0.165
	d	0.0109	0.0173	0.0274	0.0435	0.0689	0.1091	0.1722	0.2708	0.4232	0.6557	1.0032	1.5093	2.2222	3.1920	4.4590	6.0492
590.	P	510.195		741.815	1552.305	3313.507										
	h	343.906	Phase	282.781	276.896	275.432										
	s	0.42	Change	0.36	0.35	0.34										
	v	0.125		0.032	0.028	0.026										
	d	7.9697		31.0193	35.1549	38.8621										

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.																	
600.	P	1.038	1.648	2.617	4.151	6.576	10.394	16.376	25.666	39.910	61.317	92.576	136.391	194.435	265.926	346.347	427.142
	h	390.433	390.403	390.357	390.282	390.165	389.981	389.689	389.233	388.527	387.445	385.822	383.450	380.103	375.574	369.727	362.538
	s	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44
	v	118.912	74.826	47.104	29.666	18.700	11.803	7.464	4.735	3.018	1.937	1.256	0.826	0.554	0.380	0.267	0.194
	d	0.0084	0.0134	0.0212	0.0337	0.0535	0.0847	0.1340	0.2112	0.3314	0.5163	0.7961	1.2104	1.8060	2.6333	3.7402	5.1642
600.	P	497.235	547.068	571.951		673.503	1168.710	2443.899	4814.416								
	h	354.132	344.702	334.525	Phase	292.905	285.296	281.594	282.660								
	s	0.43	0.42	0.41	Change	0.37	0.36	0.35	0.34								
	v	0.144	0.111	0.086		0.035	0.030	0.027	0.025								
	d	6.9221	9.0296	11.5640		28.8917	33.0021	36.9566	40.4220								
610.	P	1.289	2.047	3.248	5.150	8.152	12.872	20.242	31.635	48.980	74.784	111.909	162.875	228.579	306.961	391.631	472.823
	h	395.403	395.368	395.311	395.221	395.079	394.855	394.503	393.952	393.106	391.817	389.904	387.144	383.317	378.232	371.802	364.060
	s	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44
	v	96.630	60.817	38.294	24.126	15.214	9.609	6.083	3.866	2.470	1.591	1.037	0.687	0.465	0.322	0.229	0.168
	d	0.0103	0.0164	0.0261	0.0414	0.0657	0.1041	0.1644	0.2587	0.4048	0.6284	0.9639	1.4550	2.1512	3.1048	4.3597	5.9487
610.	P	539.548	584.240	606.479	615.169	624.095	673.543	950.593	1815.175	3632.245							
	h	355.180	345.406	335.051	324.431	313.860	303.536	294.659	288.919	287.597							
	s	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35							
	v	0.127	0.098	0.076	0.057	0.044	0.037	0.032	0.029	0.026							
	d	7.8850	10.2113	13.2134	17.6190	22.8198	26.8881	30.7879	34.9050	38.6261							
620.	P	1.007	1.599	2.540	4.029	6.385	10.097	15.920	24.982	38.914	59.948	90.871	134.610	193.306	266.820	351.421	439.089
	h	400.433	400.406	400.362	400.293	400.184	400.013	399.740	399.316	398.654	397.640	396.113	393.868	390.681	386.335	380.680	373.678
	s	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45
	v	124.867	78.574	49.459	31.147	19.630	12.387	7.830	4.963	3.160	2.026	1.311	0.860	0.574	0.392	0.275	0.198
	d	0.0080	0.0127	0.0202	0.0321	0.0509	0.0807	0.1277	0.2015	0.3164	0.4937	0.7630	1.1634	1.7424	2.5518	3.6423	5.0543
620.	P	519.313	582.043	622.621	645.536	665.791	702.284	852.098	1397.949	2723.089							
	h	365.415	356.111	346.037	335.554	324.995	314.510	304.776	297.325	293.738							
	s	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36							
	v	0.147	0.112	0.087	0.066	0.050	0.040	0.035	0.031	0.027							
	d	6.8151	8.9426	11.5584	15.1355	20.0809	24.8208	28.6315	32.7367	36.6951							
630.	P	1.249	1.984	3.149	4.994	7.908	12.494	19.664	30.778	47.755	73.144	109.948	161.021	227.798	309.005	398.984	488.452
	h	405.473	405.440	405.386	405.302	405.171	404.961	404.634	404.120	403.327	402.118	400.314	397.701	394.046	389.151	382.914	375.346
	s	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45
	v	101.569	63.927	40.243	25.351	15.984	10.091	6.386	4.055	2.588	1.664	1.082	0.715	0.481	0.332	0.235	0.171
	d	0.0098	0.0156	0.0248	0.0394	0.0626	0.0991	0.1566	0.2466	0.3864	0.6009	0.9239	1.3992	2.0771	3.0121	4.2513	5.8314
630.	P	566.519	625.307	664.063	694.573	733.742	824.803	1149.976	2060.986	3923.840							
	h	366.607	356.934	346.655	336.134	325.609	315.437	306.688	301.058	299.838							
	s	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36							
	v	0.129	0.099	0.076	0.058	0.045	0.038	0.033	0.029	0.026							
	d	7.7705	10.1159	13.1092	17.3271	22.4298	26.5609	30.5133	34.6244	38.3645							
640.	P	0.975	1.549	2.459	3.902	6.185	9.786	15.440	24.254	37.844	58.453	88.926	132.411	191.480	266.625	355.014	449.257
	h	410.568	410.543	410.502	410.439	410.337	410.175	409.924	409.527	408.911	407.962	406.526	404.408	401.378	397.222	391.760	384.944
	s	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46
	v	131.367	82.666	52.031	32.767	20.645	13.023	8.229	5.214	3.317	2.123	1.371	0.896	0.596	0.406	0.283	0.203
	d	0.0076	0.0121	0.0192	0.0305	0.0484	0.0768	0.1215	0.1918	0.3015	0.4711	0.7295	1.1155	1.6768	2.4659	3.5378	4.9354

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.																
640.	P	539.175	614.503	670.338	712.373	757.106	828.852	1022.925	1613.952	2980.011						
	h	376.842	367.671	357.689	347.285	336.773	326.415	316.827	309.479	305.975						
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37						
	v	0.149	0.113	0.087	0.067	0.051	0.041	0.035	0.031	0.027						
	d	6.6901	8.8196	11.4321	14.9242	19.7168	24.4275	28.3251	32.4400	36.4069						
650.	P	1.208	1.919	3.046	4.832	7.653	12.098	19.058	29.868	46.434	71.335	107.685	158.639	226.220	309.748	404.566	501.866
	h	415.675	415.644	415.594	415.516	415.393	415.200	414.894	414.416	413.676	412.544	410.848	408.373	404.892	400.196	394.159	386.781
	s	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46
	v	106.970	67.319	42.377	26.690	16.825	10.620	6.717	4.262	2.717	1.744	1.132	0.745	0.500	0.343	0.242	0.175
	d	0.0093	0.0149	0.0236	0.0375	0.0594	0.0942	0.1489	0.2347	0.3681	0.5732	0.8835	1.3423	2.0008	2.9141	4.1337	5.6984
650.	P	591.004	663.784	719.623	771.234	838.788	969.647	1338.447	2288.546	4188.022							
	h	378.190	368.622	358.425	347.982	337.548	327.492	318.861	313.310	312.154							
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37							
	v	0.131	0.100	0.077	0.059	0.045	0.038	0.033	0.029	0.026							
	d	7.6326	9.9779	12.9359	17.0295	22.0082	26.2106	30.2025	34.3134	38.0768							
660.	P	0.942	1.496	2.376	3.770	5.978	9.462	14.939	23.492	36.711	56.835	86.766	129.828	188.990	265.400	357.071	457.391
	h	420.836	420.812	420.775	420.715	420.621	420.472	420.236	419.868	419.293	418.406	417.062	415.066	412.193	408.225	402.968	396.350
	s	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47
	v	138.486	87.144	54.848	34.532	21.756	13.722	8.667	5.488	3.488	2.229	1.437	0.937	0.621	0.421	0.292	0.208
	d	0.0072	0.0115	0.0182	0.0290	0.0460	0.0729	0.1154	0.1822	0.2867	0.4486	0.6960	1.0669	1.6094	2.3769	3.4266	4.8050
660.	P	556.540	644.364	715.579	776.546	845.011	949.642	1185.322	1814.913	3214.492							
	h	388.425	379.387	369.515	359.184	348.740	338.488	329.019	321.761	318.302							
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38							
	v	0.153	0.115	0.089	0.068	0.052	0.042	0.036	0.031	0.028							
	d	6.5460	8.6709	11.2655	14.6869	19.3380	24.0262	27.9928	32.1091	36.0918							
670.	P	1.165	1.851	2.939	4.664	7.390	11.687	18.426	28.911	45.033	69.367	105.140	155.760	223.766	309.231	408.394	513.126
	h	426.008	425.980	425.934	425.861	425.748	425.567	425.282	424.839	424.149	423.091	421.498	419.164	415.855	411.360	405.529	398.341
	s	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47
	v	112.872	71.029	44.711	28.157	17.747	11.198	7.079	4.488	2.858	1.833	1.186	0.779	0.520	0.356	0.249	0.180
	d	0.0089	0.0141	0.0224	0.0355	0.0563	0.0893	0.1413	0.2228	0.3498	0.5457	0.8429	1.2844	1.9220	2.8117	4.0087	5.5553
670.	P	613.099	699.532	772.391	844.800	939.280	1106.979	1514.798	2497.922	4424.995							
	h	389.906	380.483	370.371	359.993	349.651	339.708	331.178	325.669	324.542							
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38							
	v	0.134	0.102	0.079	0.060	0.046	0.039	0.033	0.029	0.026							
	d	7.4795	9.8094	12.7307	16.7169	21.5860	25.8404	29.8562	33.9740	37.7636							
680.	P	0.907	1.442	2.290	3.635	5.764	9.128	14.420	22.696	35.519	55.109	84.407	126.883	185.861	263.134	357.613	463.476
	h	431.233	431.211	431.177	431.120	431.033	430.895	430.677	430.334	429.799	428.973	427.715	425.839	423.125	419.343	414.293	407.885
	s	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
	v	146.276	92.043	57.929	36.467	22.972	14.484	9.146	5.788	3.676	2.346	1.510	0.982	0.649	0.438	0.302	0.214
	d	0.0068	0.0109	0.0173	0.0274	0.0435	0.0690	0.1093	0.1728	0.2721	0.4262	0.6624	1.0181	1.5406	2.2849	3.3100	4.6650
680.	P	571.439	671.445	757.964	837.553	928.830	1064.333	1338.174	2001.640	3426.324							
	h	400.148	391.260	381.504	371.246	360.889	350.726	341.357	334.163	330.720							
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39							
	v	0.157	0.118	0.090	0.069	0.053	0.042	0.036	0.031	0.028							
	d	6.3873	8.4995	11.0723	14.4268	18.9412	23.6140	27.6335	31.7505	35.7492							

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

680	P	[illegible]	[illegible]2	[illegible]30	[illegible]35	764	[illegible].120	[illegible].426	[illegible]2.690	35.519	55.109	80.407	126.883	185.861	263.234	357.613	463.476
	h	431.255	431.211	431.177	431.120	431.033	430.895	430.677	430.334	429.799	428.973	427.715	425.839	423.125	419.343	414.293	407.885
	s	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
	v	146.276	92.043	57.929	36.467	22.972	14.484	9.146	5.788	3.676	2.346	1.510	0.982	0.649	0.438	0.302	0.214
	d	0.0068	0.0109	0.0173	0.0274	0.0435	0.0690	0.1093	0.1728	0.2721	0.4262	0.6624	1.0181	1.5406	2.2849	3.3100	4.6650

680.	P	571.439	671.445	757.964	837.553	928.830	1064.333	1338.174	2001.640	3426.324
	h	400.148	391.260	381.504	371.246	360.889	350.726	341.357	334.163	330.720
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39
	v	0.157	0.118	0.090	0.069	0.053	0.042	0.036	0.031	0.028
	d	6.3873	8.4995	11.0723	14.4268	18.9412	23.6140	27.6335	31.7505	35.7492

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

700.	P	1.386	2.202	3.496	5.545	8.784	13.884	21.873	34.280	53.293	81.868	123.608	182.159	260.	356.622	467.456	583.739
	h	441.736	441.704	441.652	441.572	441.444	441.241	440.925	440.428	439.658	438.484	436.725	434.164	430.569	425.737	419.543	412.006
	s	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
	v	97.404	61.296	38.588	24.305	15.321	9.671	6.117	3.882	2.475	1.590	1.032	0.680	0.456	0.314	0.221	0.161
	d	0.0103	0.0163	0.0259	0.0411	0.0653	0.1034	0.1635	0.2576	0.4040	0.6290	0.9691	1.4713	2.1916	3.1881	4.5166	6.2157

700.	P	695.580	797.158	894.905	1008.308	1172.635	1480.872	2173.173	3615.583
	h	403.275	393.643	383.478	373.198	363.118	353.841	346.685	343.228
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40
	v	0.120	0.092	0.071	0.054	0.043	0.037	0.032	0.028
	d	8.3111	10.8589	14.1423	18.5324	23.1881	27.2465	31.3628	35.3788

710.	P	1.077	1.712	2.719	4.315	6.841	10.829	17.097	26.886	42.016	65.048	99.314	148.654	216.518	304.430	410.627	528.514
	h	447.057	447.033	446.992	446.931	446.834	446.679	446.435	446.052	445.457	444.536	443.145	441.080	438.116	434.027	428.631	421.861
	s	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49
	v	126.446	79.552	50.061	31.523	19.861	12.526	7.912	5.010	3.185	2.036	1.313	0.857	0.568	0.385	0.268	0.191
	d	0.0079	0.0126	0.0200	0.0317	0.0503	0.0798	0.1264	0.1996	0.3140	0.4911	0.7617	1.1672	1.7594	2.5961	3.7383	5.2345

710.	P	648.507	762.007	868.065	980.113	1125.031	1357.596	1832.005	2861.010	4816.856
	h	413.800	404.652	394.753	384.545	374.339	364.591	356.202	350.711	349.530
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40
	v	0.141	0.106	0.082	0.062	0.048	0.040	0.034	0.030	0.027
	d	7.1159	9.4115	12.2494	16.0187	20.7111	25.0392	29.0832	33.2077	37.0574

720.	P	1.330	2.113	3.355	5.322	8.433	13.337	21.027	32.996	51.395	79.178	120.042	177.904	255.825	354.165	469.347	593.326
	h	452.387	452.356	452.310	452.236	452.117	451.931	451.637	451.177	450.461	449.367	447.721	445.313	441.905	437.288	431.319	423.997
	s	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49
	v	103.291	64.994	40.915	25.769	16.240	10.248	6.479	4.108	2.617	1.678	1.087	0.714	0.477	0.327	0.229	0.166
	d	0.0097	0.0154	0.0244	0.0388	0.0616	0.0976	0.1543	0.2434	0.3821	0.5959	0.9202	1.4013	2.0955	3.0627	4.3608	6.0324

720.	P	716.520	832.817	948.180	1082.859	1273.992	1613.217	2329.510	3782.801
	h	415.438	405.942	395.876	385.675	375.669	366.469	359.332	355.826
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41
	v	0.123	0.094	0.072	0.055	0.044	0.037	0.032	0.029
	d	8.1046	10.6233	13.8345	18.1034	22.7413	26.8326	30.9452	34.9809

730.	P	1.032	1.640	2.606	4.136	6.559	10.386	16.409	25.827	40.423	62.726	96.090	144.500	211.811	300.379	409.087	532.574
	h	457.769	457.745	457.710	457.652	457.562	457.420	457.195	456.839	456.288	455.433	454.134	452.201	449.406	445.518	440.348	433.806
	s	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50
	v	134.196	84.431	53.139	33.454	21.076	13.289	8.392	5.311	3.373	2.154	1.386	0.902	0.596	0.402	0.278	0.198
	d	0.0075	0.0118	0.0188	0.0299	0.0474	0.0752	0.1192	0.1883	0.2965	0.4644	0.7215	1.1085	1.6766	2.4855	3.5953	5.0598

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.																
730.	P	661.810	788.227	910.138	1041.265	1209.208	1470.184	1971.691	3014.966	4972.613						
	h	425.945	416.951	407.188	397.055	386.929	377.255	368.912	363.390	362.130						
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41						
	v	0.145	0.109	0.084	0.064	0.049	0.041	0.035	0.031	0.027						
	d	6.9140	9.1861	11.9747	15.6448	20.2443	24.6048	28.6548	32.7820	36.6636						
740.	P	1.273	2.022	3.211	5.096	8.078	12.780	20.165	31.679	49.433	76.359	116.207	173.152	250.769	350.278	469.158	600.189
	h	463.161	463.133	463.088	463.021	462.911	462.740	462.468	462.040	461.379	460.362	458.825	456.566	453.346	448.945	443.205	436.099
	s	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50
	v	109.748	69.061	43.467	27.373	17.249	10.883	6.877	4.357	2.773	1.775	1.147	0.751	0.500	0.341	0.238	0.171
	d	0.0091	0.0145	0.0230	0.0365	0.0580	0.0919	0.1454	0.2295	0.3606	0.5632	0.8716	1.3312	1.9982	2.9340	4.1992	5.8392
740.	P	733.973	864.634	997.089	1152.090	1368.151	1735.105	2470.844	3927.673								
	h	427.748	418.385	408.435	398.306	388.373	379.236	372.095	368.514								
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42								
	v	0.127	0.096	0.074	0.057	0.045	0.038	0.033	0.029								
	d	7.8801	10.3697	13.5066	17.6587	22.2717	26.3942	30.5007	34.5538								
750.	P	0.987	1.568	2.491	3.955	6.274	9.938	15.710	24.750	38.789	60.318	92.688	140.002	206.492	295.122	405.809	534.221
	h	468.601	468.580	468.548	468.495	468.411	468.278	468.072	467.745	467.233	466.441	465.233	463.426	460.798	457.113	452.173	445.865
	s	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51
	v	142.740	89.807	56.516	35.580	22.409	14.127	8.918	5.641	3.580	2.283	1.467	0.952	0.627	0.422	0.290	0.205
	d	0.0070	0.0111	0.0177	0.0281	0.0446	0.0708	0.1121	0.1773	0.2793	0.4380	0.6818	1.0500	1.5936	2.3722	3.4480	4.8776
750.	P	671.983	810.531	948.140	1097.347	1287.080	1573.653	2098.682	3151.263								
	h	438.216	429.409	419.763	409.727	399.673	390.071	381.754	376.176								
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43								
	v	0.149	0.112	0.086	0.066	0.051	0.041	0.035	0.031								
	d	6.7	8.9394	11.6847	15.2508	19.7570	24.1424	28.1991	32.3288								
760.	P	1.216	1.931	3.067	4.868	7.718	12.217	19.290	30.336	47.416	73.428	112.149	167.963	244.914	345.018	466.886	604.184
	h	474.054	474.028	473.989	473.926	473.825	473.665	473.415	473.022	472.408	471.465	470.036	467.919	464.885	460.705	455.203	448.325
	s	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51
	v	116.848	73.526	46.278	29.140	18.359	11.579	7.314	4.632	2.945	1.883	1.214	0.793	0.526	0.357	0.248	0.177
	d	0.0086	0.0136	0.0216	0.0343	0.0545	0.0864	0.1367	0.2159	0.3396	0.5311	0.8235	1.2615	1.9005	2.8026	4.0314	5.6360
760.	P	748.155	892.342	1041.334	1215.662	1454.848	1846.309	2597.282	4049.792								
	h	440.170	430.979	421.139	411.092	401.223	392.137	384.979	381.294								
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43								
	v	0.131	0.099	0.076	0.058	0.046	0.039	0.033	0.029								
	d	7.6463	10.0969	13.1636	17.1962	21.7795	25.9313	30.0286	34.0954								
770.	P	0.941	1.496	2.377	3.773	5.987	9.487	15.004	23.658	37.125	57.842	89.143	135.214	200.561	288.840	400.850	533.458
	h	479.554	479.534	479.504	479.456	479.379	479.258	479.065	478.764	478.292	477.559	476.437	474.754	472.289	468.807	464.101	458.030
	s	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52
	v	152.134	95.720	60.233	37.916	23.879	15.050	9.497	6.005	3.808	2.426	1.556	1.008	0.662	0.443	0.303	0.213
	d	0.0066	0.0104	0.0166	0.0264	0.0419	0.0664	0.1053	0.1665	0.2626	0.4123	0.6428	0.9922	1.5106	2.2579	3.2971	4.6895
770.	P	678.987	829.122	981.349	1148.289	1358.392	1668.309	2213.341	3269.781								
	h	450.605	441.991	432.500	422.544	412.568	403.027	394.723	389.071								
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44								
	v	0.154	0.115	0.088	0.067	0.052	0.042	0.036	0.031								
	d	6.4758	8.6802	11.3725	14.8437	19.2496	23.6563	27.7194	31.8462								

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.																
780.	P	1.158	1.840	2.923	4.639	7.357	11.651	18.408	28.977	45.359	70.402	107.899	162.378	238.299	338.591	462.604	605.411
	h	485.065	485.042	485.005	484.948	484.854	484.708	484.478	484.115	483.550	482.677	481.349	479.372	476.520	472.556	467.297	460.664
	s	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52
	v	124.668	78.446	49.368	31.084	19.581	12.346	7.797	4.935	3.134	2.	1.288	0.839	0.555	0.374	0.259	0.184
	d	0.0080	0.0127	0.0203	0.0322	0.0511	0.0810	0.1283	0.2027	0.3190	0.4996	0.7762	1.1923	1.8026	2.6708	3.8600	5.4250
780.	P	758.662	915.840	1080.693	1273.367	1533.682	1946.819	2709.187	4152.981								
	h	452.725	443.708	433.993	424.026	414.225	405.177	397.981	394.167								
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44								
	v	0.135	0.102	0.078	0.060	0.047	0.039	0.034	0.030								
	d	7.3982	9.8093	12.8039	16.7187	21.2599	25.4429	29.5308	33.6113								
790.	P	0.895	1.424	2.262	3.592	5.699	9.034	14.295	22.557	35.441	55.316	85.479	130.168	194.148	281.604	394.322	530.270
	h	490.623	490.605	490.577	490.533	490.463	490.351	490.174	489.896	489.461	488.785	487.746	486.179	483.874	480.596	476.124	470.300
	s	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
	v	162.544	102.226	64.327	40.489	25.498	16.067	10.136	6.406	4.059	2.583	1.654	1.069	0.700	0.467	0.318	0.222
	d	0.0062	0.0098	0.0155	0.0247	0.0392	0.0622	0.0987	0.1561	0.2463	0.3871	0.6045	0.9353	1.4283	2.1429	3.1441	4.4953
790.	P	682.735	843.691	1010.190	1193.632	1422.877	1753.913	2315.441	3371.349								
	h	463.114	454.700	445.357	435.516	425.614	416.118	407.821	402.073								
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45								
	v	0.160	0.119	0.090	0.069	0.053	0.043	0.037	0.032								
	d	6.2409	8.4072	11.0509	14.4194	18.7206	23.1455	27.2145	31.3361								
800.	P	1.100	1.749	2.778	4.411	6.996	11.084	17.521	27.608	43.277	67.315	103.490	156.443	231.035	330.865	456.390	603.802
	h	496.193	496.172	496.138	496.084	495.998	495.864	495.652	495.318	494.799	493.991	492.762	490.922	488.246	484.502	479.492	473.107
	s	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
	v	133.327	83.870	52.781	33.227	20.928	13.193	8.328	5.268	3.344	2.132	1.370	0.890	0.586	0.394	0.271	0.192
	d	0.0075	0.0119	0.0189	0.0301	0.0478	0.0758	0.1201	0.1898	0.2991	0.4690	0.7298	1.1238	1.7053	2.5373	3.6850	5.2071
800.	P	765.565	934.950	1114.853	1324.809	1604.722	2036.210	2806.587	4236.585								
	h	465.393	456.562	446.986	437.107	427.364	418.355	411.108	407.135								
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45								
	v	0.140	0.105	0.080	0.062	0.048	0.040	0.034	0.030								
	d	7.1398	9.5085	12.4312	16.2260	20.7171	24.9268	29.0051	33.0989								
810.	P	1.351	2.147	3.410	5.413	8.583	13.587	21.454	33.744	52.757	81.728	124.913	187.271	273.519	386.262	524.762	683.267
	h	501.790	501.764	501.724	501.659	501.558	501.396	501.141	500.740	500.117	499.158	497.703	495.554	492.473	488.236	482.666	475.726
	s	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
	v	109.406	68.843	43.328	27.282	17.190	10.841	6.849	4.337	2.757	1.763	1.137	0.743	0.493	0.334	0.233	0.167
	d	0.0091	0.0145	0.0231	0.0367	0.0582	0.0922	0.1460	0.2306	0.3627	0.5671	0.8794	1.3467	2.0284	2.9896	4.2969	5.9986
810.	P	854.184	1034.129	1233.334	1480.337	1830.187	2404.647	3456.721									
	h	467.529	458.352	448.627	438.798	429.351	421.053	415.187									
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46									
	v	0.123	0.093	0.072	0.055	0.044	0.037	0.032									
	d	8.1224	10.7140	13.9841	18.1746	22.6061	26.6817	30.7986									
820.	P	1.044	1.658	2.635	4.183	6.638	10.519	16.637	26.237	41.182	64.180	98.968	150.244	223.172	322.048	448.310	599.489
	h	507.435	507.414	507.384	507.334	507.257	507.133	506.939	506.632	506.154	505.411	504.272	502.563	500.063	496.538	491.775	485.647
	s	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54
	v	142.824	89.851	56.545	35.593	22.415	14.128	8.916	5.637	3.575	2.277	1.461	0.946	0.622	0.416	0.285	0.201
	d	0.0070	0.0111	0.0177	0.0281	0.0446	0.0708	0.1122	0.1774	0.2797	0.4391	0.6846	1.0568	1.6087	2.4035	3.5079	4.9840

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-2, Thermodynamic Properties of Toluene at Even Increments of Temperature and Entropy

Temp.																
820.	P	768.748	949.525	1143.685	1369.847	1667.546	2115.615	2890.425	4301.526							
	h	478.176	469.544	460.113	450.329	440.649	431.661	424.350	420.203							
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46							
	v	0.146	0.109	0.083	0.064	0.050	0.041	0.035	0.031							
	d	6.8712	9.1941	12.0461	15.7204	20.1473	24.3884	28.4564	32.5576							
830.	P	1.280	2.034	3.231	5.128	8.133	12.881	20.353	32.045	50.178	77.916	119.491	180.028	264.656	376.991	517.033	680.639
	h	513.088	513.064	513.028	512.968	512.875	512.726	512.493	512.125	511.552	510.668	509.324	507.323	504.436	500.431	495.126	488.439
	s	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54
	v	117.340	73.832	46.467	29.254	18.430	11.621	7.338	4.644	2.950	1.884	1.213	0.790	0.522	0.353	0.244	0.174
	d	0.0085	0.0135	0.0215	0.0342	0.0543	0.0861	0.1363	0.2153	0.3390	0.5308	0.8246	1.2666	1.9147	2.8358	4.0953	5.7496
830.	P	860.569	1053.024	1267.091	1530.604	1897.373	2482.730	3526.612									
	h	480.473	471.477	461.872	452.119	442.720	434.405	428.411									
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47									
	v	0.128	0.096	0.074	0.057	0.045	0.038	0.033									
	d	7.8267	10.3640	13.5387	17.6126	22.0394	26.1295	30.2348									
840.	P	0.987	1.569	2.493	3.959	6.282	9.958	15.758	24.870	39.083	61.024	94.359	143.814	214.792	312.233	438.548	592.520
	h	518.785	518.769	518.741	518.695	518.626	518.511	518.334	518.052	517.613	516.929	515.879	514.296	511.968	508.655	504.143	498.281
	s	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55
	v	153.332	96.471	60.705	38.207	24.061	15.162	9.565	6.045	3.831	2.438	1.561	1.009	0.661	0.440	0.300	0.210
	d	0.0065	0.0104	0.0165	0.0262	0.0416	0.0660	0.1045	0.1654	0.2610	0.4102	0.6406	0.9911	1.5134	2.2705	3.3298	4.7567
840.	P	768.272	959.513	1167.143	1408.478	1722.268	2184.523	2960.075	4348.574								
	h	491.060	482.641	473.363	463.687	454.067	445.095	437.720	433.374								
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47								
	v	0.152	0.113	0.086	0.066	0.051	0.042	0.036	0.031								
	d	6.5948	8.8688	11.6524	15.2056	19.5549	23.8252	27.8800	31.9870								
850.	P	1.209	1.922	3.053	4.847	7.689	12.182	19.260	30.352	47.595	74.067	113.960	172.463	255.131	366.318	507.207	674.880
	h	524.495	524.475	524.441	524.386	524.301	524.166	523.952	523.616	523.090	522.275	521.035	519.180	516.484	512.710	507.667	501.247
	s	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55
	v	126.110	79.352	49.939	31.436	19.801	12.483	7.880	4.985	3.163	2.017	1.296	0.842	0.555	0.373	0.257	0.182
	d	0.0079	0.0126	0.0200	0.0318	0.0505	0.0801	0.1269	0.2006	0.3161	0.4957	0.7715	1.1879	1.8023	2.6813	3.8922	5.4951
850.	P	862.773	1066.913	1294.868	1573.485	1955.155	2549.287	3580.421									
	h	493.520	484.722	475.249	465.585	456.222	447.881	441.755									
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48									
	v	0.133	0.100	0.076	0.059	0.047	0.039	0.034									
	d	7.5222	10.0033	13.0846	17.0323	21.4444	25.5554	29.6410									

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
2	T	60.079	72.401	84.521	96.462	108.234	119.848		145.967	161.946	177.547	192.798	207.728	222.355	236.703	250.786	264.625
	h	0.	5.	10.	15.	20.	25.	Phase	205.	210.	215.	220.	225.	230.	235.	240.	245.
	s	0.00008	0.00959	0.01888	0.02797	0.03687	0.04559		0.35230	0.36044	0.36839	0.37614	0.38372	0.39113	0.39838	0.40549	0.41246
	v	0.018	0.018	0.019	0.019	0.019	0.019	Change	34.992	35.939	36.864	37.767	38.649	39.514	40.359	41.190	42.005
	d	54.4859	54.0842	53.6855	53.2894	52.8959	52.5046		0.0286	0.0278	0.0271	0.0265	0.0259	0.0253	0.0248	0.0243	0.0238
2	T	278.232	291.622	304.804	317.793	330.594	343.223	355.683	367.986	380.136	392.143	404.009	415.745	427.354	438.839	450.209	461.467
	h	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.	320.	325.
	s	0.41930	0.42602	0.43261	0.43910	0.44548	0.45175	0.45793	0.46402	0.47002	0.47593	0.48176	0.48751	0.49318	0.49878	0.50431	0.50977
	v	42.804	43.593	44.367	45.130	45.883	46.625	47.357	48.078	48.790	49.493	50.189	50.877	51.556	52.227	52.895	53.553
	d	0.0234	0.0229	0.0225	0.0222	0.0218	0.0214	0.0211	0.0208	0.0205	0.0202	0.0199	0.0197	0.0194	0.0191	0.0189	0.0187
2	T	472.614	483.661	494.603	505.453	516.205	526.871	537.445	547.937	558.347	568.678	578.934	589.114	599.221	609.261	619.230	629.136
	h	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.	405.
	s	0.51517	0.52050	0.52577	0.53098	0.53613	0.54123	0.54627	0.55126	0.55619	0.56108	0.56592	0.57071	0.57545	0.58015	0.58481	0.58942
	v	54.208	54.851	55.493	56.126	56.757	57.378	57.999	58.612	59.221	59.825	60.422	61.017	61.610	62.194	62.778	63.356
	d	0.0184	0.0182	0.0180	0.0178	0.0176	0.0174	0.0172	0.0171	0.0169	0.0167	0.0166	0.0164	0.0162	0.0161	0.0159	0.0158
2	T	638.976	648.754	658.468	668.126	677.729	687.272	696.764	706.199	715.588	724.922	734.205	743.445	752.635	761.779	770.879	779.935
	h	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.	485.
	s	0.59399	0.59853	0.60302	0.60747	0.61188	0.61626	0.62060	0.62491	0.62918	0.63342	0.63762	0.64179	0.64593	0.65004	0.65412	0.65817
	v	63.929	64.502	65.071	65.636	66.193	66.753	67.305	67.858	68.403	68.948	69.493	70.028	70.566	71.100	71.629	72.160
	d	0.0156	0.0155	0.0154	0.0152	0.0151	0.0150	0.0149	0.0147	0.0146	0.0145	0.0144	0.0143	0.0142	0.0141	0.0140	0.0139
2	T	788.948	797.921	806.850	815.740	824.594	833.406	842.183	850.923	859.626							
	h	490.	495.	500.	505.	510.	515.	520.	525.	530.							
	s	0.66219	0.66618	0.67014	0.67408	0.67798	0.68186	0.68572	0.68954	0.69335							
	v	72.688	73.210	73.732	74.252	74.766	75.279	75.792	76.301	76.810							
	d	0.0138	0.0137	0.0136	0.0135	0.0134	0.0133	0.0132	0.0131	0.0130							
5	T	60.065	72.385	84.508	96.447	108.219	119.831	131.296	142.625	153.816	164.888		179.049	194.186	209.009	223.546	237.811
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	Phase	215.	220.	225.	230.	235.
	s	0.00007	0.00957	0.01887	0.02795	0.03685	0.04557	0.05411	0.06249	0.07071	0.07879		0.34885	0.35659	0.36415	0.37154	0.37879
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	Change	14.626	14.993	15.352	15.702	16.045
	d	54.4874	54.0857	53.6869	53.2911	52.8974	52.5063	52.1171	51.7298	51.3442	50.9597		0.0684	0.0667	0.0651	0.0637	0.0623
5	T	251.823	265.596	279.145	292.480	305.614	318.559	331.324	343.914	356.342	368.614	380.735	392.714	404.557	416.270	427.857	439.326
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.38588	0.39284	0.39967	0.40638	0.41297	0.41945	0.42582	0.43209	0.43827	0.44435	0.45034	0.45625	0.46208	0.46782	0.47349	0.47909
	v	16.381	16.712	17.036	17.354	17.667	17.975	18.278	18.578	18.873	19.163	19.450	19.734	20.015	20.291	20.564	20.835
	d	0.0610	0.0598	0.0587	0.0576	0.0566	0.0556	0.0547	0.0538	0.0530	0.0522	0.0514	0.0507	0.0500	0.0493	0.0486	0.0480
5	T	450.673	461.916	473.047	484.078	495.006	505.842	516.582	527.232	537.797	548.279	558.676	568.999	579.243	589.415	599.513	609.546
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.48462	0.49008	0.49547	0.50080	0.50607	0.51127	0.51642	0.52152	0.52656	0.53154	0.53648	0.54136	0.54620	0.55099	0.55573	0.56043
	v	21.104	21.368	21.630	21.890	22.148	22.403	22.655	22.906	23.155	23.401	23.646	23.888	24.129	24.368	24.605	24.840
	d	0.0474	0.0468	0.0462	0.0457	0.0452	0.0446	0.0441	0.0437	0.0432	0.0427	0.0423	0.0419	0.0414	0.0410	0.0406	0.0403
5	T	619.507	629.404	639.236	649.007	658.716	668.370	677.964	687.503	696.987	706.422	715.802	725.133	734.411	743.645	752.831	761.971
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.56509	0.56970	0.57427	0.57880	0.58329	0.58774	0.59215	0.59653	0.60087	0.60518	0.60945	0.61368	0.61789	0.62206	0.62620	0.63031
	v	25.074	25.306	25.538	25.767	25.995	26.221	26.446	26.670	26.892	27.112	27.332	27.550	27.769	27.985	28.200	28.414
	d	0.0399	0.0395	0.0392	0.0388	0.0385	0.0381	0.0378	0.0375	0.0372	0.0369	0.0366	0.0363	0.0360	0.0357	0.0355	0.0352

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
5	T	771.066	780.120	789.129	798.099	807.024	815.911	824.759	833.570	842.341	851.079	859.781				
	h	480.	485.	490.	495.	500.	505.	510.	515.	520.	525.	530.				
	s	0.63438	0.63843	0.64245	0.64644	0.65040	0.65433	0.65824	0.66212	0.66597	0.66980	0.67360				
	v	28.627	28.838	29.050	29.259	29.467	29.676	29.884	30.089	30.296	30.500	30.702				
	d	0.0349	0.0347	0.0344	0.0342	0.0339	0.0337	0.0335	0.0332	0.0330	0.0328	0.0326				
10	T	60.036	72.356	84.481	96.421	108.194	119.806	131.271	142.601	153.796	164.862	175.815	186.649	197.375		211.161	225.544
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	Phase	225.	230.
	s	0.00003	0.00954	0.01883	0.02792	0.03682	0.04553	0.05408	0.06246	0.07069	0.07876	0.08670	0.09450	0.10217		0.34951	0.35689
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	Change	7.585	7.765
	d	54.4900	54.0883	53.6896	53.2936	52.9003	52.5092	52.1201	51.7330	51.3473	50.9630	50.5797	50.1977	49.8165		0.1318	0.1288
10	T	239.671	253.561	267.226	280.676	293.922	306.977	319.849	332.544	345.072	357.445	369.662	381.737	393.671	405.473	417.147	428.696
	h	235.	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.
	s	0.36411	0.37119	0.37813	0.38495	0.39164	0.39822	0.40469	0.41105	0.41731	0.42348	0.42955	0.43554	0.44144	0.44726	0.45300	0.45866
	v	7.940	8.112	8.280	8.445	8.607	8.766	8.923	9.077	9.229	9.378	9.526	9.671	9.814	9.956	10.096	10.234
	d	0.1259	0.1233	0.1208	0.1184	0.1162	0.1141	0.1121	0.1102	0.1084	0.1066	0.1050	0.1034	0.1019	0.1004	0.0990	0.0977
10	T	440.131	451.450	462.660	473.766	484.768	495.677	506.486	517.203	527.833	538.382	548.844	559.227	569.531	579.760	589.917	600.000
	h	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.
	s	0.46426	0.46978	0.47523	0.48062	0.48595	0.49121	0.49642	0.50156	0.50665	0.51169	0.51667	0.52161	0.52649	0.53132	0.53611	0.54085
	v	10.371	10.506	10.640	10.772	10.904	11.033	11.162	11.290	11.416	11.540	11.665	11.788	11.910	12.031	12.151	12.271
	d	0.0964	0.0952	0.0940	0.0928	0.0917	0.0906	0.0896	0.0886	0.0876	0.0867	0.0857	0.0848	0.0840	0.0831	0.0823	0.0815
10	T	610.018	619.967	629.852	639.674	649.435	659.133	668.776	678.359	687.889	697.363	706.787	716.159	725.480	734.752	743.980	753.158
	h	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.
	s	0.54555	0.55020	0.55481	0.55938	0.56391	0.56839	0.57284	0.57726	0.58163	0.58597	0.59027	0.59454	0.59878	0.60298	0.60715	0.61129
	v	12.389	12.507	12.624	12.739	12.855	12.969	13.083	13.196	13.308	13.421	13.531	13.642	13.751	13.861	13.969	14.077
	d	0.0807	0.0800	0.0792	0.0785	0.0778	0.0771	0.0764	0.0758	0.0751	0.0745	0.0739	0.0733	0.0727	0.0721	0.0716	0.0710
10	T	762.291	771.382	780.426	789.430	798.389	807.314	816.193	825.037	833.840	842.610	851.342	860.035				
	h	475.	480.	485.	490.	495.	500.	505.	510.	515.	520.	525.	530.				
	s	0.61540	0.61947	0.62352	0.62754	0.63153	0.63549	0.63942	0.64332	0.64720	0.65105	0.65488	0.65868				
	v	14.184	14.292	14.398	14.504	14.610	14.714	14.819	14.923	15.026	15.129	15.231	15.334				
	d	0.0705	0.0700	0.0695	0.0689	0.0684	0.0680	0.0675	0.0670	0.0665	0.0661	0.0657	0.0652				
20	T	59.978	72.301	84.423	96.369	108.142	119.758	131.224	142.552	153.749	164.818	175.770	186.607	197.333	207.955	218.473	228.893
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00004	0.00947	0.01877	0.02786	0.03676	0.04547	0.05402	0.06240	0.07063	0.07870	0.08664	0.09444	0.10211	0.10966	0.11709	0.12441
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.021
	d	54.4950	54.0933	53.6949	53.2991	52.9060	52.5150	52.1263	51.7392	51.3536	50.9697	50.5866	50.2047	49.8235	49.4428	49.0626	48.6823
20	T	239.217	249.446		270.524	283.773	296.836	309.725	322.447	335.005	347.410	359.666	371.779	383.754	395.600	407.315	418.913
	h	80.	85.	Phase	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.
	s	0.13162	0.13872		0.36367	0.37045	0.37712	0.38367	0.39012	0.39646	0.40270	0.40885	0.41491	0.42088	0.42677	0.43257	0.43830
	v	0.021	0.021	Change	4.063	4.149	4.233	4.315	4.396	4.475	4.553	4.630	4.706	4.781	4.854	4.927	4.998
	d	48.3019	47.9208		0.2461	0.2410	0.2362	0.2317	0.2275	0.2234	0.2196	0.2160	0.2125	0.2092	0.2060	0.2030	0.2001
20	T	430.392	441.755	453.013	464.163	475.211	486.163	497.020	507.785	518.459	529.049	539.556	549.982	560.328	570.601	580.797	590.924
	h	310.	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.
	s	0.44396	0.44954	0.45505	0.46050	0.46588	0.47119	0.47645	0.48165	0.48679	0.49187	0.49690	0.50188	0.50681	0.51168	0.51651	0.52129
	v	5.069	5.139	5.207	5.276	5.343	5.410	5.476	5.541	5.606	5.670	5.733	5.796	5.859	5.921	5.982	6.043
	d	0.1973	0.1946	0.1920	0.1896	0.1872	0.1848	0.1826	0.1805	0.1784	0.1764	0.1744	0.1725	0.1707	0.1689	0.1672	0.1655

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
20	T	600.980	610.968	620.891	630.752	640.548	650.286	659.962	669.585	679.152	688.660	698.117	707.523	716.877	726.184	735.440	744.647
	h	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.
	s	0.52603	0.53072	0.53537	0.53998	0.54454	0.54907	0.55355	0.55800	0.56241	0.56678	0.57112	0.57542	0.57968	0.58392	0.58812	0.59228
	v	6.103	6.164	6.223	6.282	6.341	6.399	6.457	6.514	6.571	6.628	6.685	6.741	6.796	6.852	6.907	6.962
	d	0.1638	0.1622	0.1607	0.1592	0.1577	0.1563	0.1549	0.1535	0.1522	0.1509	0.1496	0.1484	0.1471	0.1460	0.1448	0.1436
20	T	753.814	762.933	772.009	781.042	790.033	798.981	807.890	816.762	825.595	834.387	843.143	851.866	860.552			
	h	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.	520.	525.	530.			
	s	0.59642	0.60053	0.60460	0.60865	0.61266	0.61665	0.62061	0.62454	0.62844	0.63232	0.63617	0.63999	0.64379			
	v	7.016	7.070	7.124	7.178	7.231	7.285	7.337	7.390	7.442	7.494	7.546	7.598	7.649			
	d	0.1425	0.1414	0.1404	0.1393	0.1383	0.1373	0.1363	0.1353	0.1344	0.1334	0.1325	0.1316	0.1307			
50	T	59.806	72.132	84.262	96.211	107.988	119.606	131.077	142.410	153.608	164.682	175.639	186.478	197.209	207.835	218.357	228.781
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00024	0.00927	0.01857	0.02767	0.03657	0.04528	0.05383	0.06222	0.07044	0.07852	0.08646	0.09426	0.10194	0.10949	0.11692	0.12424
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.021
	d	54.5101	54.1090	53.7107	53.3154	52.9226	52.5321	52.1439	51.7573	51.3724	50.9888	50.6067	50.2254	49.8449	49.4648	49.0852	48.7056
50	T	239.104	249.340	259.482	269.535	279.502	289.376	299.171	308.879	318.506		342.596	354.607	366.496	378.278	389.942	401.503
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	Phase	270.	275.	280.	285.	290.	295.
	s	0.13145	0.13855	0.14555	0.15246	0.15927	0.16599	0.17262	0.17917	0.18563		0.37777	0.38396	0.39006	0.39607	0.40199	0.40784
	v	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	Change	1.712	1.746	1.780	1.813	1.845	1.877
	d	48.3261	47.9462	47.5659	47.1847	46.8024	46.4186	46.0333	45.6459	45.2562		0.5840	0.5726	0.5618	0.5517	0.5420	0.5329
50	T	412.958	424.312	435.561	446.715	457.775	468.741	479.616	490.406	501.108	511.733	522.271	532.734	543.120	553.432	563.670	573.840
	h	300.	305.	310.	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.
	s	0.41360	0.41930	0.42492	0.43047	0.43595	0.44137	0.44672	0.45202	0.45725	0.46242	0.46754	0.47261	0.47762	0.48258	0.48749	0.49235
	v	1.908	1.938	1.968	1.998	2.027	2.056	2.085	2.113	2.141	2.168	2.195	2.222	2.249	2.275	2.301	2.327
	d	0.5242	0.5159	0.5080	0.5005	0.4933	0.4863	0.4797	0.4733	0.4671	0.4612	0.4555	0.4500	0.4447	0.4396	0.4346	0.4298
50	T	583.938	593.971	603.943	613.847	623.689	633.474	643.200	652.865	662.476	672.034	681.539	690.991	700.390	709.740	719.042	728.298
	h	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.
	s	0.49717	0.50194	0.50666	0.51134	0.51597	0.52057	0.52512	0.52964	0.53411	0.53855	0.54295	0.54731	0.55164	0.55593	0.56019	0.56442
	v	2.353	2.378	2.403	2.428	2.453	2.477	2.501	2.525	2.549	2.573	2.596	2.620	2.643	2.666	2.689	2.712
	d	0.4251	0.4205	0.4162	0.4119	0.4077	0.4037	0.3998	0.3960	0.3923	0.3887	0.3851	0.3817	0.3783	0.3751	0.3719	0.3687
50	T	737.508	746.671	755.792	764.868	773.904	782.897	791.848	800.758	809.633	818.468	827.265	836.030	844.754	853.446	862.102	
	h	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.	520.	525.	530.	
	s	0.56861	0.57277	0.57690	0.58100	0.58507	0.58910	0.59311	0.59709	0.60105	0.60497	0.60887	0.61274	0.61659	0.62041	0.62421	
	v	2.735	2.757	2.779	2.802	2.824	2.846	2.868	2.889	2.911	2.933	2.954	2.975	2.996	3.017	3.038	
	d	0.3657	0.3627	0.3598	0.3569	0.3541	0.3514	0.3487	0.3461	0.3435	0.3410	0.3385	0.3361	0.3337	0.3314	0.3291	
100	T	59.522	71.856	83.990	95.946	107.730	119.354	130.832	142.168	153.377	164.454	175.417	186.264	196.998	207.632	218.159	228.591
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00057	0.00895	0.01824	0.02734	0.03625	0.04497	0.05352	0.06191	0.07014	0.07822	0.08616	0.09397	0.10165	0.10920	0.11663	0.12396
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.021
	d	54.5351	54.1345	53.7373	53.3425	52.9505	52.5609	52.1732	51.7876	51.4036	51.0210	50.6396	50.2596	49.8801	49.5015	49.1233	48.7449
100	T	238.921	249.164	259.312	269.370	279.346	289.231	299.032	308.750	318.385	327.939	337.411	346.804	356.113	365.340	374.486	383.549
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.13116	0.13827	0.14527	0.15218	0.15899	0.16571	0.17235	0.17889	0.18536	0.19175	0.19806	0.20429	0.21046	0.21656	0.22258	0.22854
	v	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023	0.024
	d	48.3667	47.9881	47.6094	47.2297	46.8490	46.4674	46.0840	45.6987	45.3114	44.9217	44.5292	44.1334	43.7338	43.3298	42.9216	42.5086

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
100	T		400.802	411.831	422.799	433.701	444.535	455.305	466.006	476.640	487.203	497.704	508.132	518.498	528.803	539.035	549.206
	h	Phase	290.	295.	300.	305.	310.	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.
	s		0.38852	0.39429	0.39999	0.40562	0.41118	0.41668	0.42212	0.42749	0.43280	0.43805	0.44324	0.44838	0.45347	0.45850	0.46348
	v	Change	0.864	0.882	0.899	0.916	0.933	0.950	0.966	0.982	0.998	1.013	1.028	1.043	1.058	1.072	1.087
	d		1.1579	1.1343	1.1122	1.0913	1.0716	1.0530	1.0353	1.0185	1.0025	0.9873	0.9727	0.9588	0.9455	0.9326	0.9203
100	T	559.320	569.366	579.356	589.286	599.157	608.974	618.731	628.436	638.087	647.684	657.233	666.726	676.172	685.572	694.922	704.225
	h	365.	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.
	s	0.46841	0.47329	0.47813	0.48292	0.48766	0.49236	0.49702	0.50163	0.50621	0.51074	0.51524	0.51970	0.52412	0.52850	0.53285	0.53716
	v	1.101	1.115	1.129	1.142	1.156	1.169	1.182	1.195	1.208	1.221	1.234	1.247	1.259	1.271	1.284	1.296
	d	0.9085	0.8971	0.8861	0.8755	0.8653	0.8554	0.8458	0.8366	0.8276	0.8189	0.8105	0.8022	0.7942	0.7865	0.7790	0.7717
100	T	713.483	722.698	731.865	740.995	750.077	759.121	768.126	777.088	786.015	794.899	803.746	812.559	821.337	830.079	838.782	847.454
	h	445.	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.	520.
	s	0.54144	0.54569	0.54990	0.55408	0.55823	0.56235	0.56644	0.57049	0.57452	0.57852	0.58249	0.58644	0.59035	0.59424	0.59811	0.60194
	v	1.308	1.320	1.332	1.344	1.356	1.367	1.379	1.390	1.402	1.413	1.424	1.436	1.447	1.458	1.469	1.480
	d	0.7645	0.7576	0.7508	0.7442	0.7377	0.7314	0.7253	0.7193	0.7134	0.7077	0.7020	0.6966	0.6912	0.6859	0.6808	0.6757
100	T	856.096															
	h	525.															
	s	0.60576															
	v	1.491															
	d	0.6708															
200	T	58.952	71.298	83.447	95.415	107.211	118.849	130.339	141.687	152.904	163.997	174.969	185.830	196.579	207.220	217.761	228.205
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00124	0.00828	0.01759	0.02670	0.03561	0.04434	0.05290	0.06129	0.06953	0.07762	0.08557	0.09338	0.10106	0.10862	0.11606	0.12339
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.5849	54.1857	53.7897	53.3965	53.0060	52.6179	52.2319	51.8480	51.4658	51.0853	50.7058	50.3274	49.9502	49.5737	49.1982	48.8222
200	T	238.551	248.805	258.968	269.044	279.029	288.930	298.750	308.485	318.138	327.711	337.205	346.618	355.950	365.200	374.377	383.468
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.13060	0.13771	0.14471	0.15162	0.15844	0.16516	0.17180	0.17835	0.18482	0.19120	0.19752	0.20376	0.20992	0.21602	0.22205	0.22801
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023	0.023
	d	48.4465	48.0713	47.6954	47.3186	46.9416	46.5629	46.1835	45.8024	45.4193	45.0347	44.6467	44.2562	43.8628	43.4649	43.0639	42.6580
200	T	392.479	401.408	410.252	419.014	427.690	436.269	444.756	453.153		464.355	474.134	483.937	493.747	503.554	513.355	523.138
	h	160.	165.	170.	175.	180.	185.	190.	195.	Phase	310.	315.	320.	325.	330.	335.	340.
	s	0.23391	0.23974	0.24552	0.25124	0.25690	0.26251	0.26806	0.27357		0.39873	0.40411	0.40944	0.41471	0.41992	0.42509	0.43020
	v	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.026	Change	0.411	0.422	0.432	0.442	0.451	0.460	0.470
	d	42.2462	41.8298	41.4002	40.9445	40.4788	40.0009	39.5105	39.0059		2.4321	2.3719	2.3162	2.2648	2.2167	2.1718	2.1296
200	T	532.903	542.644	552.355	562.040	571.690	581.312	590.894	600.444	609.957	619.430	628.866	638.267	647.625	656.947	666.231	675.479
	h	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.
	s	0.43526	0.44028	0.44524	0.45016	0.45503	0.45985	0.46464	0.46937	0.47407	0.47872	0.48334	0.48791	0.49244	0.49694	0.50140	0.50582
	v	0.478	0.487	0.496	0.504	0.512	0.520	0.528	0.536	0.544	0.551	0.559	0.566	0.574	0.581	0.588	0.595
	d	2.0900	2.0526	2.0172	1.9837	1.9518	1.9216	1.8926	1.8651	1.8387	1.8134	1.7891	1.7659	1.7434	1.7219	1.7011	1.6811
200	T	684.685	693.858	702.990	712.086	721.148	730.169	739.157	748.111	757.027	765.908	774.754	783.571	792.352	801.097	809.813	818.498
	h	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.
	s	0.51021	0.51456	0.51888	0.52316	0.52741	0.53163	0.53582	0.53997	0.54410	0.54819	0.55226	0.55629	0.56030	0.56428	0.56823	0.57216
	v	0.602	0.609	0.615	0.622	0.629	0.635	0.642	0.648	0.655	0.661	0.667	0.674	0.680	0.686	0.692	0.698
	d	1.6616	1.6430	1.6248	1.6073	1.5903	1.5739	1.5579	1.5424	1.5273	1.5127	1.4984	1.4845	1.4710	1.4578	1.4449	1.4324

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
200	T	827.152	835.773	844.362	852.923	861.453										
	h	505.	510.	515.	520.	525.										
	s	0.57606	0.57993	0.58378	0.58760	0.59140										
	v	0.704	0.710	0.716	0.722	0.728										
	d	1.4202	1.4083	1.3966	1.3853	1.3741										
300	T	58.375	70.740	82.903	94.883	106.692	118.342	129.845	141.207	152.435	163.539	174.525	185.393	196.152	206.810	217.363	227.816
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00192	0.00762	0.01694	0.02606	0.03498	0.04372	0.05228	0.06068	0.06893	0.07702	0.08498	0.09279	0.10048	0.10804	0.11549	0.12281
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.6345	54.2365	53.8419	53.4499	53.0609	52.6745	52.2900	51.9078	51.5272	51.1484	50.7711	50.3953	50.0200	49.6457	49.2719	48.8988
300	T	238.176	248.443	258.621	268.709	278.711	288.627	298.465	308.215	317.885	327.474	336.987	346.422	355.776	365.052	374.251	383.366
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.13003	0.13714	0.14416	0.15107	0.15789	0.16461	0.17125	0.17780	0.18427	0.19066	0.19698	0.20322	0.20939	0.21548	0.22151	0.22747
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023	0.023
	d	48.5259	48.1532	47.7799	47.4066	47.0326	46.6574	46.2820	45.9044	45.5259	45.1450	44.7619	44.3767	43.9882	43.5965	43.2016	42.8019
300	T	392.407	401.367	410.250	419.047	427.759	436.393	444.930	453.376	461.735	469.984	478.126	486.160	494.066	501.846	509.473	
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	Phase
	s	0.23337	0.23921	0.24499	0.25071	0.25637	0.26198	0.26753	0.27303	0.27848	0.28388	0.28924	0.29455	0.29981	0.30504	0.31021	
	v	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.028	0.028	Change
	d	42.3983	41.9893	41.5709	41.1325	40.6861	40.2300	39.7627	39.2839	38.7935	38.2886	37.7673	37.2310	36.6749	36.0987	35.4997	
300	T	513.540	522.222	531.029	539.918	548.874	557.877	566.920	575.984	585.066	594.158	603.252	612.346	621.426	630.502	639.564	648.607
	h	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.
	s	0.40820	0.41332	0.41839	0.42341	0.42839	0.43333	0.43822	0.44307	0.44787	0.45264	0.45736	0.46205	0.46669	0.47130	0.47587	0.48040
	v	0.258	0.266	0.274	0.281	0.288	0.295	0.302	0.309	0.315	0.321	0.327	0.333	0.339	0.345	0.351	0.356
	d	3.8800	3.7619	3.6555	3.5584	3.4694	3.3873	3.3114	3.2406	3.1746	3.1127	3.0545	2.9997	2.9477	2.8985	2.8519	2.8074
300	T	657.635	666.643	675.629	684.597	693.537	702.456	711.347	720.218	729.057	737.869	746.661	755.423	764.158	772.864	781.546	790.197
	h	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.
	s	0.48489	0.48935	0.49377	0.49816	0.50251	0.50683	0.51111	0.51537	0.51959	0.52378	0.52794	0.53207	0.53617	0.54024	0.54428	0.54830
	v	0.362	0.367	0.372	0.377	0.383	0.388	0.393	0.398	0.402	0.407	0.412	0.417	0.421	0.426	0.430	0.435
	d	2.7691	2.7247	2.6861	2.6492	2.6136	2.5797	2.5469	2.5155	2.4851	2.4556	2.4275	2.4002	2.3738	2.3481	2.3234	2.2993
300	T	798.825	807.427	816.	824.547	833.070	841.562	850.031	858.473								
	h	485.	490.	495.	500.	505.	510.	515.	520.								
	s	0.55228	0.55624	0.56018	0.56408	0.56796	0.57182	0.57565	0.57945								
	v	0.439	0.444	0.448	0.452	0.457	0.461	0.465	0.469								
	d	2.2760	2.2534	2.2314	2.2101	2.1893	2.1690	2.1493	2.1301								
400	T	57.798	70.178	82.357	94.349	106.171	117.833	129.347	140.719	151.959	163.076	174.072	184.954	195.726	206.391	216.957	227.423
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00259	0.00696	0.01629	0.02541	0.03434	0.04309	0.05166	0.06007	0.06832	0.07642	0.08438	0.09220	0.09990	0.10746	0.11491	0.12224
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.6837	54.2870	53.8936	53.5032	53.1156	52.7306	52.3478	51.9673	51.5884	51.2113	50.8361	50.4616	50.0886	49.7166	49.3451	48.9744
400	T	237.798	248.077	258.267	268.367	278.383	288.317	298.165	307.933	317.622	327.229	336.761	346.213	355.589	364.886	374.110	383.250
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12947	0.13658	0.14360	0.15051	0.15733	0.16406	0.17071	0.17726	0.18373	0.19013	0.19644	0.20268	0.20885	0.21495	0.22098	0.22694
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023
	d	48.6038	48.2337	47.8635	47.4930	47.1220	46.7505	46.3779	46.0047	45.6299	45.2529	44.8746	44.4939	44.1107	43.7245	43.3357	42.9421

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
400	T	392.321	401.313	410.221	419.056	427.805	436.478	445.063	453.563	461.976	470.288	478.512	486.626	494.638	502.524	510.276	517.894
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23284	0.23868	0.24446	0.25018	0.25584	0.26145	0.26700	0.27250	0.27795	0.28335	0.28870	0.29401	0.29927	0.30449	0.30966	0.31480
	v	0.024	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.027	0.028	0.028
	d	42.5454	42.1441	41.7348	41.3099	40.8769	40.4363	39.9857	39.5263	39.0563	38.5723	38.0773	37.5670	37.0431	36.4994	35.9359	35.3512
400	T	525.359	532.634	539.701	546.515		559.443	567.164	575.094	583.188	591.416	599.742	608.153	616.620	625.147	633.707	642.299
	h	240.	245.	250.	255.	Phase	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.
	s	0.31989	0.32495	0.32997	0.33496		0.41922	0.42411	0.42896	0.43377	0.43855	0.44329	0.44799	0.45265	0.45728	0.46187	0.46643
	v	0.029	0.029	0.030	0.031	Change	0.184	0.191	0.198	0.204	0.210	0.215	0.221	0.226	0.231	0.237	0.241
	d	34.7419	34.1027	33.4315	32.7157		5.4202	5.2287	5.0582	4.9056	4.7675	4.6412	4.5256	4.4187	4.3200	4.2279	4.1418
400	T	650.911	659.538	668.180	676.822	685.471	694.113	702.755	711.388	720.013	728.623	737.224	745.807	754.378	762.937	771.472	779.991
	h	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.
	s	0.47095	0.47543	0.47988	0.48430	0.48868	0.49303	0.49735	0.50163	0.50589	0.51011	0.51430	0.51846	0.52260	0.52670	0.53078	0.53482
	v	0.246	0.251	0.256	0.260	0.264	0.269	0.273	0.277	0.281	0.285	0.289	0.293	0.297	0.301	0.305	0.308
	d	4.0610	3.9850	3.9135	3.8458	3.7819	3.7207	3.6630	3.6077	3.5551	3.5046	3.4564	3.4099	3.3655	3.3230	3.2818	3.2421
400	T	788.489	796.972	805.435	813.878	822.299	830.701	839.082	847.444	855.782							
	h	475.	480.	485.	490.	495.	500.	505.	510.	515.							
	s	0.53884	0.54284	0.54680	0.55074	0.55465	0.55854	0.56240	0.56624	0.57005							
	v	0.312	0.316	0.319	0.323	0.326	0.330	0.333	0.337	0.340							
	d	3.2038	3.1670	3.1315	3.0970	3.0635	3.0313	2.9998	2.9695	2.9400							
500	T	57.221	69.616	81.806	93.814	105.649	117.323	128.847	140.232	151.485	162.612	173.619	184.512	195.295	205.973	216.551	227.029
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00326	0.00630	0.01564	0.02477	0.03371	0.04246	0.05104	0.05946	0.06772	0.07582	0.08379	0.09162	0.09931	0.10689	0.11434	0.12167
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.7328	54.3372	53.9452	53.5560	53.1697	52.7862	52.4051	52.0259	51.6490	51.2736	50.9000	50.5277	50.1567	49.7866	49.4173	49.0492
500	T	237.413	247.705	257.909	268.023	278.051	287.999	297.863	307.647	317.348	326.975	336.523	345.996	355.389	364.710	373.951	383.122
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12890	0.13602	0.14304	0.14996	0.15678	0.16352	0.17016	0.17672	0.18319	0.18959	0.19591	0.20215	0.20832	0.21442	0.22045	0.22642
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023
	d	48.6812	48.3134	47.9457	47.5780	47.2101	46.8417	46.4726	46.1031	45.7314	45.3589	44.9846	44.6088	44.2302	43.8495	43.4657	43.0787
500	T	392.215	401.233	410.173	419.039	427.830	436.538	445.163	453.707	462.172	470.548	478.828	487.011	495.102	503.091	510.948	518.697
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23232	0.23815	0.24393	0.24965	0.25531	0.26092	0.26647	0.27197	0.27742	0.28282	0.28817	0.29348	0.29874	0.30395	0.30912	0.31425
	v	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.028	0.028
	d	42.6881	42.2937	41.8923	41.4783	41.0577	40.6292	40.1923	39.7476	39.2936	38.8295	38.3535	37.8653	37.3632	36.8497	36.3165	35.7652
500	T	526.318	533.782	541.073	548.187	555.074	561.703	567.983	573.860	579.131		583.180	588.818	595.054	601.743	608.769	616.048
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	Phase	340.	345.	350.	355.	360.	365.
	s	0.31934	0.32439	0.32941	0.33438	0.33933	0.34424	0.34912	0.35399	0.35880		0.41649	0.42128	0.42603	0.43076	0.43545	0.44012
	v	0.028	0.029	0.029	0.030	0.031	0.031	0.032	0.033	0.034	Change	0.125	0.132	0.138	0.144	0.150	0.155
	d	35.1958	34.6023	33.9807	33.3332	32.6465	31.9235	31.1462	30.3057	29.3850		8.0106	7.5913	7.2389	6.9373	6.6741	6.4410
500	T	623.544	631.206	639.008	646.914	654.913	662.982	671.115	679.293	687.514	695.767	704.047	712.344	720.659	728.979	737.308	745.641
	h	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.
	s	0.44475	0.44935	0.45392	0.45845	0.46295	0.46742	0.47186	0.47627	0.48064	0.48498	0.48929	0.49358	0.49783	0.50205	0.50624	0.51040
	v	0.160	0.165	0.170	0.175	0.179	0.184	0.188	0.192	0.196	0.200	0.204	0.207	0.211	0.215	0.218	0.222
	d	6.2332	6.0461	5.8765	5.7211	5.5786	5.4466	5.3243	5.2101	5.1037	5.0038	4.9100	4.8212	4.7376	4.6578	4.5825	4.5107

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
500	T	753.976	762.308	770.635	778.960	787.275	795.581	803.875	812.160	820.439	828.699	836.945	845.177	853.396	861.602	
	h	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.	
	s	0.51454	0.51864	0.52272	0.52677	0.53080	0.53479	0.53876	0.54271	0.54662	0.55052	0.55439	0.55823	0.56205	0.56585	
	v	0.225	0.228	0.232	0.235	0.238	0.241	0.245	0.248	0.251	0.254	0.257	0.260	0.262	0.265	
	d	4.4424	4.3771	4.3146	4.2549	4.1975	4.1423	4.0895	4.0385	3.9897	3.9425	3.8968	3.8526	3.8098	3.7686	
600	T		56.642	69.048	81.255	93.275	105.123	116.809	128.344	139.742	151.005	162.144	173.162	184.067	194.862	205.553	216.141
	h		0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.
	s		-0.00393	0.00564	0.01499	0.02413	0.03308	0.04184	0.05042	0.05885	0.06711	0.07522	0.08319	0.09103	0.09873	0.10631	0.11377
	v		0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020
	d		54.7815	54.3871	53.9964	53.6085	53.2236	52.8416	52.4618	52.0845	51.7088	51.3355	50.9637	50.5931	50.2241	49.8560	49.4889
600	T	226.631	237.027	247.332	257.546	267.674	277.716	287.677	297.557	307.351	317.072	326.714	336.279	345.767	355.181	364.522	373.787
	h	75.	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.
	s	0.12111	0.12834	0.13546	0.14248	0.14941	0.15623	0.16297	0.16962	0.17617	0.18265	0.18905	0.19537	0.20162	0.20779	0.21389	0.21992
	v	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023
	d	49.1228	48.7570	48.3920	48.0269	47.6621	47.2973	46.9318	46.5661	46.1995	45.8316	45.4630	45.0928	44.7210	44.3471	43.9713	43.5928
600	T	382.979	392.097	401.138	410.110	419.005	427.825	436.570	445.233	453.821	462.326	470.751	479.095	487.344	495.502	503.562	511.520
	h	155.	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.
	s	0.22589	0.23179	0.23763	0.24341	0.24913	0.25479	0.26039	0.26594	0.27145	0.27689	0.28229	0.28764	0.29294	0.29820	0.30341	0.30858
	v	0.023	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.027
	d	43.2114	42.8270	42.4387	42.0455	41.6406	41.2291	40.8121	40.3877	39.9554	39.5151	39.0662	38.6079	38.1389	37.6579	37.1641	36.6565
600	T	519.382	527.111	534.722	542.188	549.509	556.651	563.610	570.320	576.768	582.872	588.589	593.715	598.199	601.778	604.216	605.539
	h	235.	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.
	s	0.31371	0.31880	0.32385	0.32886	0.33383	0.33877	0.34367	0.34854	0.35337	0.35819	0.36297	0.36773	0.37246	0.37718	0.38194	0.38651
	v	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.033	0.034	0.035	0.036	0.038	0.040	0.043
	d	36.1360	35.5940	35.0370	34.4576	33.8559	33.2256	32.5680	31.8759	31.1477	30.3653	29.5365	28.6292	27.6405	26.5163	25.1121	23.4051
600	T	606.003		606.393	606.923	608.190	610.418	613.652	617.778	622.638	628.103	634.054	640.387	647.026	653.930	661.044	668.328
	h	315.	Phase	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.
	s	0.39129		0.40068	0.40540	0.41004	0.41471	0.41938	0.42403	0.42866	0.43326	0.43785	0.44241	0.44694	0.45144	0.45592	0.46037
	v	0.047	Change	0.061	0.070	0.078	0.085	0.092	0.099	0.105	0.110	0.115	0.120	0.125	0.130	0.134	0.138
	d	21.1658		16.3653	14.3561	12.8737	11.7378	10.8535	10.1478	9.5682	9.0842	8.6706	8.3120	7.9960	7.7165	7.4663	7.2397
600	T	675.755	683.308	690.958	698.695	706.494	714.363	722.278	730.234	738.223	746.238	754.281	762.342	770.414	778.500	786.592	794.688
	h	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.
	s	0.46478	0.46917	0.47353	0.47786	0.48217	0.48644	0.49068	0.49490	0.49909	0.50325	0.50738	0.51148	0.51556	0.51961	0.52364	0.52764
	v	0.142	0.146	0.150	0.154	0.157	0.161	0.164	0.167	0.171	0.174	0.177	0.180	0.183	0.186	0.189	0.192
	d	7.0338	6.8458	6.6726	6.5130	6.3638	6.2259	6.0964	5.9753	5.8612	5.7533	5.6516	5.5554	5.4639	5.3769	5.2942	5.2150
600	T	802.787	810.886	818.987	827.085	835.174	843.261	851.335	859.410								
	h	475.	480.	485.	490.	495.	500.	505.	510.								
	s	0.53161	0.53556	0.53948	0.54338	0.54725	0.55110	0.55493	0.55873								
	v	0.195	0.197	0.200	0.203	0.205	0.208	0.211	0.213								
	d	5.1395	5.0668	4.9977	4.9314	4.8673	4.8058	4.7463	4.6895								
700	T	56.061	68.482	80.703	92.735	104.596	116.292	127.841	139.253	150.526	161.676	172.703	183.620	194.425	205.126	215.727	226.229
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00460	0.00498	0.01433	0.02349	0.03244	0.04121	0.04981	0.05824	0.06651	0.07463	0.08260	0.09044	0.09815	0.10573	0.11319	0.12054
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.8300	54.4369	54.0473	53.6607	53.2771	52.8965	52.5182	52.1422	51.7684	51.3964	51.0264	50.6580	50.2906	49.9248	49.5597	49.1958

T in F. P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
700	T	236.634	246.953	257.178	267.319	277.376	287.345	297.240	307.053	316.786	326.444	336.023	345.531	354.963	364.321	373.607	382.821
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12777	0.13490	0.14193	0.14885	0.15568	0.16242	0.16907	0.17564	0.18212	0.18852	0.19484	0.20108	0.20726	0.21336	0.21939	0.22536
	v	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023
	d	48.8323	48.4695	48.1072	47.7450	47.3831	47.0201	46.6575	46.2940	45.9299	45.5648	45.1986	44.8308	44.4613	44.0903	43.7166	43.3405
700	T	391.959	401.030	410.026	418.947	427.795	436.573	445.273	453.900	462.449	470.915	479.305	487.611	495.831	503.960	512.007	519.945
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23126	0.23710	0.24288	0.24860	0.25427	0.25987	0.26542	0.27092	0.27637	0.28177	0.28711	0.29242	0.29767	0.30288	0.30805	0.31318
	v	0.023	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.027
	d	42.9615	42.5801	42.1933	41.7957	41.3933	40.9864	40.5720	40.1524	39.7240	39.2881	38.8444	38.3908	37.9272	37.4528	36.9681	36.4687
700	T	527.780	535.514	543.110	550.598	557.928	565.103	572.113	578.923	585.484	591.785	597.733	603.315	608.434	612.965	616.842	620.060
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.31826	0.32330	0.32831	0.33328	0.33821	0.34311	0.34796	0.35279	0.35759	0.36236	0.36711	0.37182	0.37651	0.38118	0.38583	0.39048
	v	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.033	0.034	0.035	0.036	0.037	0.039	0.041
	d	35.9555	35.4284	34.8805	34.3173	33.7306	33.1191	32.4874	31.8253	31.1273	30.3979	29.6150	28.7920	27.9122	26.9521	25.8818	24.6415
700	T	622.767	625.267	627.743	630.336	633.125	636.196	639.632	643.494	647.822	652.629	657.869	663.501	669.480	675.747	682.273	689.003
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.39508	0.39971	0.40432	0.40892	0.41349	0.41806	0.42262	0.42716	0.43168	0.43618	0.44067	0.44513	0.44957	0.45399	0.45838	0.46275
	v	0.043	0.047	0.051	0.056	0.061	0.067	0.072	0.078	0.083	0.088	0.093	0.097	0.101	0.106	0.109	0.113
	d	23.1886	21.5014	19.7083	17.9500	16.3605	14.9825	13.8239	12.8569	12.0486	11.3702	10.7923	10.2937	9.8595	9.4761	9.1354	8.8300
700	T	695.924	703.	710.206	717.525	724.944	732.447	740.020	747.657	755.338	763.070	770.838	778.642	786.468	794.320	802.184	810.067
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.46709	0.47140	0.47569	0.47995	0.48418	0.48839	0.49257	0.49672	0.50085	0.50495	0.50903	0.51308	0.51711	0.52111	0.52508	0.52903
	v	0.117	0.120	0.124	0.127	0.130	0.134	0.137	0.140	0.143	0.145	0.148	0.151	0.154	0.156	0.159	0.162
	d	8.5538	8.3038	8.0739	7.8627	7.6684	7.4876	7.3191	7.1623	7.0147	6.8766	6.7462	6.6234	6.5070	6.3965	6.2914	6.1917
700	T	817.965	825.868	833.779	841.692	849.610	857.528										
	h	480.	485.	490.	495.	500.	505.										
	s	0.53296	0.53686	0.54073	0.54459	0.54842	0.55223										
	v	0.164	0.167	0.169	0.171	0.174	0.176										
	d	6.0967	6.0055	5.9188	5.8353	5.7555	5.6787										
800	T		55.479	67.915	80.148	92.195	104.068	115.778	127.339	138.758	150.044	161.202	172.244	183.170	193.985	204.698	215.308
	h		0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.
	s		-0.00528	0.00431	0.01368	0.02284	0.03181	0.04059	0.04919	0.05763	0.06590	0.07403	0.08201	0.08986	0.09757	0.10515	0.11262
	v		0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020
	d		54.8781	54.4861	54.0977	53.7124	53.3302	52.9508	52.5742	52.1996	51.8275	51.4572	51.0887	50.7219	50.3565	49.9927	49.6298
800	T	225.824	236.240	246.568	256.807	266.960	277.027	287.014	296.917	306.746	316.494	326.170	335.766	345.286	354.735	364.111	373.416
	h	75.	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.
	s	0.11997	0.12721	0.13434	0.14137	0.14830	0.15513	0.16188	0.16853	0.17510	0.18158	0.18798	0.19430	0.20055	0.20673	0.21283	0.21887
	v	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023
	d	49.2679	48.9069	48.5464	48.1864	47.8267	47.4670	47.1075	46.7478	46.3874	46.0267	45.6654	45.3026	44.9387	44.5733	44.2063	43.8374
800	T	382.650	391.812	400.906	409.924	418.872	427.751	436.557	445.288	453.949	462.535	471.048	479.480	487.840	496.115	504.308	512.410
	h	155.	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.
	s	0.22484	0.23074	0.23658	0.24236	0.24808	0.25374	0.25935	0.26490	0.27040	0.27585	0.28125	0.28659	0.29189	0.29715	0.30236	0.30752
	v	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027
	d	43.4665	43.0931	42.7173	42.3364	41.9475	41.5530	41.1539	40.7493	40.3387	39.9219	39.4983	39.0669	38.6281	38.1803	37.7229	37.2547

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
800	T	520.429	528.347	536.171	543.887	551.496	558.984	566.333	573.554	580.610	587.484	594.164	600.608	606.789	612.674	618.213	623.363
	h	235.	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.
	s	0.31264	0.31772	0.32276	0.32777	0.33273	0.33766	0.34255	0.34740	0.35223	0.35702	0.36178	0.36651	0.37121	0.37588	0.38053	0.38516
	v	0.027	0.028	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.033	0.034	0.035	0.036	0.037
	d	36.7763	36.2852	35.7812	35.2623	34.7288	34.1789	33.6078	33.0186	32.4065	31.7679	31.1035	30.4076	29.6773	28.9119	28.1034	27.2449
800	T	628.097	632.423	636.426	640.227	643.969	647.724	651.575	655.567	659.741	664.136	668.766	673.664	678.832	684.265	689.954	695.891
	h	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.
	s	0.38977	0.39436	0.39893	0.40348	0.40803	0.41254	0.41705	0.42154	0.42601	0.43047	0.43491	0.43933	0.44374	0.44812	0.45248	0.45682
	v	0.038	0.039	0.041	0.044	0.046	0.049	0.053	0.057	0.061	0.065	0.070	0.074	0.078	0.082	0.085	0.089
	d	26.3219	25.3169	24.2045	22.9740	21.6341	20.2414	18.8560	17.5467	16.3518	15.2946	14.3662	13.5614	12.8611	12.2474	11.7090	11.2320
800	T	702.058	708.425	714.980	721.696	728.554	735.539	742.635	749.829	757.113	764.462	771.881	779.353	786.878	794.449	802.052	809.688
	h	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.
	s	0.46113	0.46542	0.46969	0.47394	0.47816	0.48235	0.48652	0.49067	0.49479	0.49889	0.50296	0.50701	0.51103	0.51503	0.51900	0.52296
	v	0.093	0.096	0.099	0.102	0.105	0.108	0.111	0.114	0.117	0.120	0.122	0.125	0.127	0.130	0.132	0.135
	d	10.8077	10.4261	10.0820	9.7696	9.4838	9.2218	8.9805	8.7574	8.5501	8.3563	8.1753	8.0055	7.8461	7.6959	7.5543	7.4196
800	T	817.349	825.039	832.748	840.469	848.202	855.948										
	h	475.	480.	485.	490.	495.	500.										
	s	0.52688	0.53079	0.53467	0.53852	0.54236	0.54617										
	v	0.137	0.139	0.142	0.144	0.146	0.148										
	d	7.2920	7.1710	7.0558	6.9457	6.8406	6.7400										
900	T		54.894	67.345	79.594	91.652	103.537	115.260	126.831	138.262	149.558	160.731	171.783	182.719	193.546	204.266	214.887
	h		0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.
	s		-0.00595	0.00365	0.01303	0.02220	0.03117	0.03996	0.04857	0.05701	0.06530	0.07343	0.08142	0.08927	0.09699	0.10458	0.11205
	v		0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020
	d		54.9260	54.5352	54.1478	53.7638	53.3830	53.0050	52.6297	52.2566	51.8861	51.5173	51.1505	50.7856	50.4218	50.0599	49.6991
900	T	225.414	235.842	246.183	256.433	266.597	276.678	286.676	296.595	306.432	316.196	325.884	335.496	345.033	354.500	363.895	373.219
	h	75.	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.
	s	0.11941	0.12665	0.13379	0.14082	0.14775	0.15459	0.16133	0.16799	0.17455	0.18104	0.18745	0.19377	0.20002	0.20620	0.21231	0.21834
	v	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023
	d	49.3391	48.9804	48.6221	48.2643	47.9071	47.5503	47.1933	46.8365	46.4793	46.1218	45.7635	45.4045	45.0444	44.6834	44.3202	43.9562
900	T	382.471	391.653	400.767	409.808	418.779	427.683	436.516	445.284	453.973	462.592	471.144	479.623	488.017	496.346	504.593	512.753
	h	155.	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.
	s	0.22431	0.23022	0.23606	0.24184	0.24756	0.25322	0.25883	0.26438	0.26988	0.27533	0.28073	0.28607	0.29137	0.29662	0.30183	0.30700
	v	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027
	d	43.5897	43.2211	42.8509	42.4758	42.0932	41.7068	41.3154	40.9195	40.5174	40.1102	39.6976	39.2786	38.8511	38.4178	37.9748	37.5223
900	T	520.842	528.836	536.745	544.552	552.266	559.869	567.361	574.745	581.979	589.077	596.026	602.799	609.369	615.735	621.863	627.731
	h	235.	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.
	s	0.31211	0.31720	0.32223	0.32723	0.33219	0.33711	0.34200	0.34685	0.35166	0.35645	0.36120	0.36592	0.37062	0.37528	0.37991	0.38452
	v	0.027	0.027	0.028	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.032	0.032	0.033	0.034	0.034	0.035
	d	37.0629	36.5906	36.1084	35.6124	35.1044	34.5821	34.0441	33.4913	32.9190	32.3238	31.7120	31.0753	30.4127	29.7246	29.0077	28.2599
900	T	633.317	638.623	643.654	648.457	653.103	657.671	662.219	666.808	671.474	676.240	681.135	686.167	691.370	696.733	702.276	707.997
	h	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.
	s	0.38911	0.39368	0.39822	0.40274	0.40724	0.41173	0.41619	0.42064	0.42507	0.42948	0.43387	0.43825	0.44260	0.44693	0.45125	0.45554
	v	0.036	0.038	0.039	0.040	0.042	0.044	0.046	0.049	0.051	0.055	0.058	0.061	0.064	0.068	0.071	0.074
	d	27.4780	26.6564	25.7887	24.8653	23.8781	22.8253	21.7156	20.5765	19.4427	18.3473	17.3196	16.3728	15.5188	14.7505	14.0642	13.4518

h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
900	T	713.893	719.950	726.171	732.548	739.065	745.713	752.477	759.351	766.317	773.371	780.510	787.713	794.979	802.303	809.673	817.087
	h	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.
	s	0.45981	0.46406	0.46829	0.47249	0.47668	0.48084	0.48497	0.48908	0.49317	0.49724	0.50128	0.50530	0.50930	0.51328	0.51723	0.52115
	v	0.077	0.081	0.084	0.086	0.089	0.092	0.095	0.097	0.100	0.102	0.105	0.107	0.110	0.112	0.114	0.116
	d	12.9032	12.4096	11.9642	11.5616	11.1941	10.8593	10.5512	10.2671	10.0035	9.7589	9.5318	9.3184	9.1188	8.9316	8.7549	8.5883
900	T	824.537	832.023	839.534	847.076	854.637	862.216										
	h	475.	480.	485.	490.	495.	500.										
	s	0.52506	0.52894	0.53280	0.53664	0.54045	0.54425										
	v	0.119	0.121	0.123	0.125	0.127	0.129										
	d	8.4305	8.2810	8.1387	8.0039	7.8752	7.7520										
1000	T		54.307	66.773	79.036	91.107	103.004	114.738	126.322	137.765	149.072	160.255	171.317	182.263	193.098	203.834	214.466
	h		0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.
	s		-0.00662	0.00299	0.01238	0.02156	0.03054	0.03933	0.04795	0.05640	0.06469	0.07283	0.08083	0.08868	0.09641	0.10400	0.11148
	v		0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020
	d		54.9737	54.5840	54.1978	53.8151	53.4355	53.0589	52.6849	52.3133	51.9442	51.5770	51.2118	50.8486	50.4868	50.1263	49.7674
1000	T	225.	235.442	245.793	256.054	266.230	276.322	286.333	296.262	306.116	315.893	325.592	335.222	344.774	354.254	363.666	373.008
	h	75.	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.
	s	0.11884	0.12609	0.13323	0.14026	0.14720	0.15404	0.16079	0.16744	0.17402	0.18050	0.18691	0.19324	0.19949	0.20567	0.21178	0.21782
	v	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.023	0.023
	d	49.4100	49.0529	48.6969	48.3414	47.9868	47.6322	47.2781	46.9243	46.5700	46.2156	45.8599	45.5047	45.1479	44.7907	44.4316	44.0719
1000	T	382.277	391.480	400.613	409.678	418.674	427.600	436.458	445.249	453.976	462.630	471.208	479.724	488.164	496.537	504.832	513.049
	h	155.	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.
	s	0.22379	0.22970	0.23554	0.24132	0.24704	0.25271	0.25831	0.26387	0.26937	0.27481	0.28021	0.28556	0.29085	0.29611	0.30131	0.30648
	v	0.023	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.026
	d	43.7098	43.3463	42.9804	42.6117	42.2352	41.8550	41.4710	41.0827	40.6899	40.2921	39.8882	39.4790	39.0634	38.6419	38.2122	37.7749
1000	T	521.189	529.252	537.230	545.119	552.921	560.630	568.238	575.738	583.137	590.391	597.554	604.543	611.403	618.093	624.608	630.933
	h	235.	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.
	s	0.31159	0.31667	0.32170	0.32670	0.33166	0.33658	0.34146	0.34631	0.35112	0.35590	0.36064	0.36536	0.37004	0.37469	0.37932	0.38391
	v	0.027	0.027	0.027	0.028	0.028	0.029	0.029	0.029	0.030	0.030	0.031	0.032	0.032	0.033	0.034	0.034
	d	37.3286	36.8750	36.4114	35.9361	35.4497	34.9524	34.4420	33.9159	33.3784	32.8190	32.2502	31.6563	31.0463	30.4158	29.7638	29.0896
1000	T	637.056	642.973	648.683	654.195	659.546	664.769	669.921	675.039	680.166	685.326	690.547	695.845	701.239	706.736	712.347	718.080
	h	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.
	s	0.38848	0.39303	0.39756	0.40206	0.40653	0.41099	0.41543	0.41984	0.42424	0.42862	0.43298	0.43731	0.44163	0.44593	0.45020	0.45446
	v	0.035	0.036	0.037	0.038	0.039	0.041	0.042	0.044	0.046	0.048	0.050	0.053	0.055	0.058	0.061	0.064
	d	28.3927	27.6716	26.9253	26.1513	25.3470	24.5068	23.6285	22.7121	21.7670	20.8067	19.8477	18.9157	18.0234	17.1845	16.4071	15.6937
1000	T	723.933	729.906	736.003	742.224	748.560	755.002	761.559	768.212	774.959	781.788	788.704	795.684	802.737	809.854	817.021	824.238
	h	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.
	s	0.45869	0.46291	0.46710	0.47127	0.47542	0.47955	0.48365	0.48773	0.49180	0.49583	0.49985	0.50384	0.50782	0.51177	0.51569	0.51960
	v	0.066	0.069	0.072	0.075	0.077	0.080	0.082	0.085	0.087	0.089	0.092	0.094	0.096	0.098	0.100	0.102
	d	15.0414	14.4460	13.9052	13.4125	12.9627	12.5500	12.1726	11.8242	11.5023	11.2038	10.9267	10.6673	10.4251	10.1987	9.9853	9.7841
1000	T	831.503	838.805	846.144	853.517	860.912											
	h	475.	480.	485.	490.	495.											
	s	0.52348	0.52734	0.53118	0.53500	0.53880											
	v	0.104	0.106	0.108	0.110	0.112											
	d	9.5944	9.4151	9.2453	9.0838	8.9295											

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-3, Thermodynamic Properties of Toluene at Even Increments of Pressure and Enthalpy

Press.																
1200	T		53.132	65.626	77.915	90.014	101.935	113.692	125.299	136.763	148.093	159.296	170.379	181.344	192.203	202.958	213.612
	h		0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.
	s		-0.00797	0.00167	0.01108	0.02028	0.02927	0.03808	0.04672	0.05518	0.06349	0.07164	0.07965	0.08751	0.09525	0.10285	0.11034
	v		0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020
	d		55.0681	54.6807	54.2969	53.9164	53.5393	53.1652	52.7938	52.4252	52.0590	51.6947	51.3328	50.9729	50.6145	50.2578	49.9026
1200	T	224.170	234.631	245.003	255.285	265.482	275.599	285.633	295.588	305.464	315.267	324.994	334.650	344.231	353.742	363.187	372.560
	h	75.	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.
	s	0.11771	0.12496	0.13211	0.13916	0.14610	0.15295	0.15970	0.16637	0.17294	0.17944	0.18585	0.19218	0.19844	0.20462	0.21073	0.21677
	v	0.020	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023
	d	49.5487	49.1959	48.8441	48.4934	48.1430	47.7932	47.4441	47.0952	46.7466	46.3978	46.0488	45.6996	45.3497	45. 2	44.6484	44.2963
1200	T	381.865	391.102	400.271	409.377	418.414	427.387	436.297	445.135	453.914	462.624	471.270	479.852	488.361	496.806	505.186	513.492
	h	155.	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.
	s	0.22275	0.22866	0.23450	0.24029	0.24601	0.25168	0.25729	0.26284	0.26834	0.27379	0.27918	0.28453	0.28983	0.29508	0.30028	0.30544
	v	0.023	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026
	d	43.9426	43.5876	43.2315	42.8724	42.5075	42.1393	41.7688	41.3940	41.0155	40.6333	40.2475	39.8567	39.4599	39.0583	38.6519	38.2382
1200	T	521.732	529.905	537.997	546.021	553.967	561.826	569.616	577.312	584.927	592.452	599.886	607.204	614.428	621.541	628.539	635.416
	h	235.	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.
	s	0.31056	0.31563	0.32066	0.32566	0.33061	0.33552	0.34040	0:34524	0.35004	0.35481	0.35954	0.36425	0.36892	0.37356	0.37817	0.38275
	v	0.026	0.027	0.027	0.027	0.028	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.032	0.033
	d	37.8189	37.3935	36.9588	36.5184	36.0689	35.6092	35.1419	34.6635	34.1747	33.6766	33.1666	32.6415	32.1050	31.5560	30.9927	30.4169
1200	T	642.171	648.798	655.292	661.660	667.905	674.038	680.071	686.024	691.921	697.778	703.619	709.467	715.327	721.219	727.146	733.125
	h	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.
	s	0.38730	0.39182	0.39632	0.40079	0.40524	0.40966	0.41406	0.41844	0.42279	0.42712	0.43143	0.43571	0.43998	0.44423	0.44845	0.45266
	v	0.034	0.034	0.035	0.036	0.037	0.037	0.038	0.039	0.041	0.042	0.043	0.044	0.046	0.047	0.049	0.051
	d	29.8270	29.2243	28.6089	27.9814	27.3426	26.6937	26.0335	25.3622	24.6799	23.9837	23.2739	22.5545	21.8245	21.0957	20.3700	19.6556
1200	T	739.156	745.248	751.399	757.624	763.912	770.264	776.688	783.177	789.734	796.356	803.037	809.779	816.577	823.431	830.331	837.284
	h	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.
	s	0.45683	0.46099	0.46513	0.46925	0.47335	0.47742	0.48148	0.48551	0.48952	0.49352	0.49749	0.50144	0.50536	0.50927	0.51316	0.51702
	v	0.053	0.055	0.057	0.059	0.061	0.063	0.065	0.067	0.069	0.071	0.073	0.074	0.076	0.078	0.080	0.082
	d	18.9633	18.2960	17.6588	17.0569	16.4883	15.9550	15.4572	14.9916	14.5587	14.1547	13.7771	13.4242	13.0949	12.7860	12.4955	12.2229
1200	T	844.279	851.313	858.386													
	h	475.	480.	485.													
	s	0.52087	0.52469	0.52850													
	v	0.084	0.085	0.087													
	d	11.9659	11.7226	11.4930													

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-4, Saturation Thermodynamic Properties of Toluene at Even Increments of Temperature and Quality

Temp																
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
60.	P	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330	0.330
	h	-0.035	54.186	90.334	126.481	162.629	166.244	169.858	173.473	177.088	177.992	178.895	179.438	179.799	180.341	180.522	180.703
	s	0.00002	0.10436	0.17392	0.24348	0.31303	0.31999	0.32694	0.33390	0.34086	0.34259	0.34433	0.34538	0.34607	0.34712	0.34746	0.34781
	v	0.018	54.995	91.647	128.298	164.949	168.614	172.279	175.945	179.610	180.526	181.442	181.992	182.359	182.908	183.092	183.275
	d	54.4874	0.0182	0.0109	0.0078	0.0061	0.0059	0.0058	0.0057	0.0056	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055	0.0055
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
70.	P	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447
	h	4.017	57.815	93.680	129.545	165.411	168.997	172.584	176.170	179.757	180.654	181.550	182.088	182.447	182.985	183.164	183.343
	s	0.00774	0.10931	0.17702	0.24473	0.31245	0.31922	0.32599	0.33276	0.33953	0.34122	0.34292	0.34393	0.34461	0.34562	0.34596	0.34630
	v	0.018	41.343	68.892	96.441	123.991	126.746	129.501	132.255	135.010	135.699	136.388	136.801	137.077	137.490	137.628	137.765
	d	54.1617	0.0242	0.0145	0.0104	0.0081	0.0079	0.0077	0.0076	0.0074	0.0074	0.0073	0.0073	0.0073	0.0073	0.0073	0.0073
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
80.	P	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597	0.597
	h	8.123	61.496	97.077	132.658	168.240	171.798	175.356	178.914	182.472	183.362	184.251	184.785	185.141	185.675	185.853	186.030
	s	0.01542	0.11432	0.18025	0.24618	0.31211	0.31870	0.32530	0.33189	0.33848	0.34013	0.34178	0.34277	0.34343	0.34442	0.34475	0.34508
	v	0.019	31.482	52.457	73.433	94.408	96.506	98.604	100.701	102.799	103.323	103.847	104.162	104.372	104.686	104.791	104.896
	d	53.8335	0.0318	0.0191	0.0136	0.0106	0.0104	0.0101	0.0099	0.0097	0.0097	0.0096	0.0096	0.0096	0.0096	0.0095	0.0095
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
90.	P	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789	0.789
	h	12.283	65.225	100.520	135.815	171.110	174.640	178.169	181.699	185.228	186.111	186.993	187.523	187.876	188.405	188.581	188.758
	s	0.02306	0.11937	0.18358	0.24779	0.31200	0.31842	0.32484	0.33127	0.33769	0.33929	0.34090	0.34186	0.34250	0.34347	0.34379	0.34411
	v	0.019	24.255	40.413	56.571	72.729	74.345	75.960	77.576	79.192	79.596	80.000	80.242	80.404	80.646	80.727	80.808
	d	53.5031	0.0412	0.0247	0.0177	0.0137	0.0135	0.0132	0.0129	0.0126	0.0126	0.0125	0.0125	0.0124	0.0124	0.0124	0.0124
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
100.	P	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029	1.029
	h	16.494	69.004	104.011	139.017	174.024	177.525	181.025	184.526	188.027	188.902	189.777	190.302	190.652	191.177	191.352	191.527
	s	0.03065	0.12447	0.18702	0.24957	0.31212	0.31838	0.32463	0.33088	0.33714	0.33870	0.34027	0.34121	0.34183	0.34277	0.34308	0.34339
	v	0.019	18.908	31.501	44.094	56.687	57.946	59.205	60.465	61.724	62.039	62.354	62.543	62.668	62.857	62.920	62.983
	d	53.1704	0.0529	0.0317	0.0227	0.0176	0.0173	0.0169	0.0165	0.0162	0.0161	0.0160	0.0160	0.0160	0.0159	0.0159	0.0159
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
110.	P	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329	1.329
	h	20.755	72.833	107.551	142.269	176.987	180.459	183.930	187.402	190.874	191.742	192.610	193.131	193.478	193.999	194.172	194.346
	s	0.03820	0.12961	0.19056	0.25150	0.31244	0.31854	0.32463	0.33073	0.33682	0.33835	0.33987	0.34078	0.34139	0.34231	0.34261	0.34292
	v	0.019	14.900	24.821	34.741	44.662	45.654	46.646	47.638	48.630	48.878	49.126	49.275	49.374	49.523	49.573	49.622
	d	52.8359	0.0671	0.0403	0.0288	0.0224	0.0219	0.0214	0.0210	0.0206	0.0205	0.0204	0.0203	0.0203	0.0202	0.0202	0.0202
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
120.	P	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697	1.697
	h	25.067	76.708	111.135	145.563	179.990	183.433	186.876	190.318	193.761	194.622	195.482	195.999	196.343	196.859	197.032	197.204
	s	0.04570	0.13478	0.19417	0.25357	0.31296	0.31890	0.32484	0.33077	0.33671	0.33820	0.33968	0.34057	0.34117	0.34206	0.34236	0.34265
	v	0.019	11.858	19.751	27.644	35.537	36.326	37.115	37.904	38.694	38.891	39.088	39.207	39.286	39.404	39.444	39.483
	d	52.4987	0.0843	0.0506	0.0362	0.0281	0.0275	0.0269	0.0264	0.0258	0.0257	0.0256	0.0255	0.0255	0.0254	0.0254	0.0253
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
130.	P	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146	2.146
	h	29.426	80.628	114.762	148.897	183.032	186.445	189.859	193.272	196.685	197.539	198.392	198.904	199.246	199.758	199.928	200.099
	s	0.05315	0.13998	0.19787	0.25576	0.31364	0.31943	0.32522	0.33101	0.33680	0.33825	0.33969	0.34056	0.34114	0.34201	0.34230	0.34259
	v	0.019	9.525	15.863	22.200	28.538	29.171	29.805	30.439	31.073	31.231	31.390	31.485	31.548	31.643	31.675	31.706
	d	52.1597	0.1050	0.0630	0.0450	0.0350	0.0343	0.0336	0.0329	0.0322	0.0320	0.0319	0.0318	0.0317	0.0316	0.0316	0.0315

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-4, Saturation Thermodynamic Properties of Toluene at Even Increments of Temperature and Quality

Temp																
140.	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
	P	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688	2.688
	h	33.833	84.594	118.435	152.276	186.117	189.501	192.885	196.269	199.653	200.499	201.345	201.853	202.191	202.699	202.868	203.037
	s	0.06056	0.14520	0.20164	0.25807	0.31450	0.32015	0.32579	0.33143	0.33707	0.33849	0.33990	0.34074	0.34131	0.34215	0.34244	0.34272
	v	0.019	7.723	12.858	17.993	23.129	23.643	24.156	24.670	25.183	25.312	25.440	25.517	25.568	25.645	25.671	25.697
	d	51.8183	0.1295	0.0778	0.0556	0.0432	0.0423	0.0414	0.0405	0.0397	0.0395	0.0393	0.0392	0.0391	0.0390	0.0390	0.0389
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
150.	P	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338	3.338
	h	38.286	88.603	122.147	155.692	189.236	192.591	195.945	199.300	202.654	203.493	204.331	204.834	205.170	205.673	205.841	206.009
	s	0.06792	0.15045	0.20547	0.26049	0.31551	0.32101	0.32651	0.33202	0.33752	0.33889	0.34027	0.34109	0.34164	0.34247	0.34275	0.34302
	v	0.019	6.312	10.507	14.702	18.897	19.316	19.736	20.155	20.575	20.680	20.785	20.848	20.890	20.952	20.973	20.994
	d	51.4748	0.1584	0.0952	0.0680	0.0529	0.0518	0.0507	0.0496	0.0486	0.0484	0.0481	0.0480	0.0479	0.0477	0.0477	0.0476
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
160.	P	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111	4.111
	h	42.785	92.654	125.899	159.145	192.391	195.715	199.040	202.364	205.689	206.520	207.351	207.850	208.182	208.681	208.847	209.013
	s	0.07523	0.15571	0.20936	0.26301	0.31666	0.32202	0.32739	0.33275	0.33812	0.33946	0.34080	0.34161	0.34214	0.34295	0.34322	0.34348
	v	0.020	5.199	8.652	12.105	15.558	15.904	16.249	16.594	16.940	17.026	17.112	17.164	17.198	17.250	17.268	17.285
	d	51.1288	0.1923	0.1156	0.0826	0.0643	0.0629	0.0615	0.0603	0.0590	0.0587	0.0584	0.0583	0.0581	0.0580	0.0579	0.0579
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
170.	P	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022	5.022
	h	47.330	96.748	129.693	162.639	195.584	198.879	202.173	205.468	208.762	209.586	210.410	210.904	211.233	211.727	211.892	212.057
	s	0.08250	0.16098	0.21331	0.26563	0.31795	0.32318	0.32841	0.33365	0.33888	0.34019	0.34149	0.34228	0.34280	0.34359	0.34385	0.34411
	v	0.020	4.316	7.180	10.045	12.909	13.195	13.482	13.768	14.054	14.126	14.198	14.241	14.269	14.312	14.327	14.341
	d	50.7804	0.2317	0.1393	0.0996	0.0775	0.0758	0.0742	0.0726	0.0712	0.0708	0.0704	0.0702	0.0701	0.0699	0.0698	0.0697
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
180.	P	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090	6.090
	h	51.919	100.883	133.526	166.169	198.811	202.076	205.340	208.604	211.869	212.685	213.501	213.990	214.317	214.806	214.970	215.133
	s	0.08973	0.16627	0.21730	0.26833	0.31936	0.32447	0.32957	0.33467	0.33978	0.34105	0.34233	0.34309	0.34360	0.34437	0.34462	0.34488
	v	0.020	3.608	6.000	8.393	10.785	11.024	11.263	11.503	11.742	11.802	11.861	11.897	11.921	11.957	11.969	11.981
	d	50.4300	0.2771	0.1667	0.1192	0.0927	0.0907	0.0888	0.0869	0.0852	0.0847	0.0843	0.0841	0.0839	0.0836	0.0835	0.0835
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
190.	P	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333	7.333
	h	56.552	105.059	137.398	169.736	202.074	205.308	208.542	211.775	215.009	215.818	216.626	217.111	217.435	217.920	218.081	218.243
	s	0.09691	0.17157	0.22135	0.27112	0.32090	0.32588	0.33085	0.33583	0.34081	0.34205	0.34330	0.34405	0.34454	0.34529	0.34554	0.34579
	v	0.020	3.037	5.049	7.060	9.071	9.272	9.474	9.675	9.876	9.926	9.976	10.007	10.027	10.057	10.067	10.077
	d	50.0769	0.3293	0.1981	0.1416	0.1102	0.1078	0.1056	0.1034	0.1013	0.1007	0.1002	0.0999	0.0997	0.0994	0.0993	0.0992
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
200.	P	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772	8.772
	h	61.230	109.274	141.303	173.333	205.362	208.565	211.768	214.971	218.174	218.974	219.775	220.256	220.576	221.056	221.216	221.377
	s	0.10404	0.17687	0.22543	0.27398	0.32253	0.32739	0.33224	0.33710	0.34196	0.34317	0.34438	0.34511	0.34560	0.34632	0.34657	0.34681
	v	0.020	2.571	4.272	5.973	7.674	7.844	8.014	8.184	8.354	8.397	8.439	8.465	8.482	8.507	8.516	8.524
	d	49.7211	0.3889	0.2341	0.1674	0.1303	0.1275	0.1248	0.1222	0.1197	0.1191	0.1185	0.1181	0.1179	0.1175	0.1174	0.1173
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
210.	P	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427	10.427
	h	65.952	113.528	145.245	176.962	208.680	211.851	215.023	218.195	221.366	222.159	222.952	223.428	223.745	224.221	224.380	224.538
	s	0.11114	0.18218	0.22954	0.27690	0.32427	0.32900	0.33374	0.33848	0.34321	0.34440	0.34558	0.34629	0.34676	0.34747	0.34771	0.34795
	v	0.020	2.190	3.636	5.082	6.529	6.673	6.818	6.962	7.107	7.143	7.179	7.201	7.216	7.237	7.245	7.252
	d	49.3627	0.4567	0.2750	0.1968	0.1532	0.1499	0.1467	0.1436	0.1407	0.1400	0.1393	0.1389	0.1386	0.1382	0.1380	0.1379

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-4, Saturation Thermodynamic Properties of Toluene at Even Increments of Temperature and Quality

Temp		q 0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
220.	P	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319	12.319
	h	70.716	117.820	149.222	180.625	212.027	215.167	218.307	221.448	224.588	225.373	226.158	226.629	226.943	227.414	227.571	227.728
	s	0.11819	0.18749	0.23369	0.27989	0.32610	0.33072	0.33534	0.33996	0.34458	0.34573	0.34689	0.34758	0.34804	0.34874	0.34897	0.34920
	v	0.020	1.676	3.112	4.349	5.586	5.710	5.833	5.957	6.081	6.111	6.142	6.161	6.173	6.192	6.198	6.204
	d	49.0016	0.5332	0.3213	0.2299	0.1790	0.1751	0.1714	0.1679	0.1645	0.1636	0.1628	0.1623	0.1620	0.1615	0.1613	0.1612
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
230.	P	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472	14.472
	h	75.526	122.152	153.236	184.320	215.404	218.512	221.621	224.729	227.837	228.615	229.392	229.858	230.169	230.635	230.790	230.946
	s	0.12520	0.19281	0.23788	0.28295	0.32802	0.33252	0.33703	0.34154	0.34604	0.34717	0.34830	0.34897	0.34942	0.35010	0.35033	0.35055
	v	0.021	1.615	2.678	3.742	4.805	4.911	5.017	5.124	5.230	5.256	5.283	5.299	5.310	5.326	5.331	5.336
	d	48.6371	0.6191	0.3734	0.2673	0.2081	0.2036	0.1993	0.1952	0.1912	0.1902	0.1893	0.1887	0.1883	0.1878	0.1876	0.1874
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
240.	P	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909	16.909
	h	80.376	126.517	157.278	188.038	218.799	221.875	224.951	228.027	231.103	231.872	232.641	233.102	233.410	233.871	234.025	234.179
	s	0.13217	0.19811	0.24208	0.28604	0.33000	0.33440	0.33880	0.34319	0.34759	0.34869	0.34979	0.35045	0.35089	0.35155	0.35177	0.35199
	v	0.021	1.397	2.315	3.233	4.151	4.242	4.334	4.426	4.518	4.541	4.564	4.577	4.587	4.600	4.605	4.610
	d	48.2704	0.7156	0.4319	0.3093	0.2409	0.2357	0.2307	0.2259	0.2213	0.2202	0.2191	0.2185	0.2180	0.2174	0.2172	0.2169
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
250.	P	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652	19.652
	h	85.273	130.924	161.358	191.792	222.226	225.269	228.313	231.356	234.399	235.160	235.921	236.378	236.682	237.138	237.291	237.443
	s	0.13910	0.20343	0.24631	0.28920	0.33208	0.33637	0.34066	0.34495	0.34924	0.35031	0.35138	0.35202	0.35245	0.35310	0.35331	0.35353
	v	0.021	1.216	2.012	2.808	3.605	3.684	3.764	3.844	3.923	3.943	3.963	3.975	3.983	3.995	3.999	4.003
	d	47.8994	0.8227	0.4970	0.3561	0.2774	0.2714	0.2657	0.2602	0.2549	0.2536	0.2523	0.2516	0.2511	0.2503	0.2501	0.2498
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
260.	P	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733	22.733
	h	90.213	135.367	165.469	195.572	225.674	228.684	231.694	234.705	237.715	238.468	239.220	239.672	239.973	240.424	240.575	240.725
	s	0.14600	0.20874	0.25057	0.29240	0.33422	0.33841	0.34259	0.34677	0.35096	0.35200	0.35305	0.35367	0.35409	0.35472	0.35493	0.35514
	v	0.021	1.062	1.756	2.449	3.143	3.213	3.282	3.351	3.421	3.438	3.455	3.466	3.473	3.483	3.487	3.490
	d	47.5250	0.9418	0.5696	0.4083	0.3181	0.3113	0.3047	0.2984	0.2923	0.2909	0.2894	0.2885	0.2880	0.2871	0.2868	0.2865
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
270.	P	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175	26.175
	h	95.195	139.843	169.609	199.374	229.140	232.116	235.093	238.069	241.046	241.790	242.534	242.981	243.278	243.725	243.874	244.023
	s	0.15285	0.21404	0.25484	0.29563	0.33642	0.34050	0.34458	0.34866	0.35274	0.35376	0.35478	0.35539	0.35580	0.35641	0.35661	0.35682
	v	0.021	0.931	1.538	2.145	2.751	2.812	2.873	2.933	2.994	3.009	3.024	3.033	3.039	3.049	3.052	3.055
	d	47.1476	1.0738	0.6502	0.4663	0.3635	0.3556	0.3481	0.3409	0.3340	0.3323	0.3307	0.3297	0.3290	0.3280	0.3277	0.3274
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
280.	P	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007	30.007
	h	100.223	144.360	173.784	203.209	232.633	235.576	238.518	241.461	244.403	245.139	245.874	246.316	246.610	247.051	247.198	247.345
	s	0.15968	0.21935	0.25913	0.29891	0.33869	0.34267	0.34664	0.35062	0.35460	0.35559	0.35659	0.35719	0.35758	0.35818	0.35838	0.35858
	v	0.021	0.820	1.353	1.886	2.419	2.472	2.525	2.578	2.632	2.645	2.658	2.666	2.672	2.680	2.682	2.685
	d	46.7657	1.2189	0.7390	0.5303	0.4135	0.4046	0.3960	0.3878	0.3800	0.3781	0.3762	0.3751	0.3743	0.3732	0.3728	0.3725
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
290.	P	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257	34.257
	h	105.296	148.909	177.985	207.061	236.136	239.044	241.952	244.859	247.767	248.494	249.221	249.657	249.947	250.384	250.529	250.674
	s	0.16646	0.22464	0.26343	0.30221	0.34099	0.34487	0.34875	0.35263	0.35651	0.35748	0.35845	0.35903	0.35942	0.36000	0.36019	0.36039
	v	0.022	0.725	1.194	1.663	2.133	2.179	2.226	2.273	2.320	2.332	2.344	2.351	2.355	2.362	2.365	2.367
	d	46.3796	1.3789	0.8373	0.6012	0.4689	0.4588	0.4492	0.4399	0.4310	0.4288	0.4267	0.4254	0.4246	0.4233	0.4229	0.4225

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-4, Saturation Thermodynamic Properties of Toluene at Even Increments of Temperature and Quality

Temp																
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
300.	P	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953	38.953
	h	110.411	153.493	182.214	210.936	239.657	242.529	245.401	248.274	251.146	251.864	252.582	253.013	253.300	253.731	253.874	254.018
	s	0.17322	0.22993	0.26774	0.30554	0.34335	0.34713	0.35091	0.35469	0.35847	0.35942	0.36036	0.36093	0.36131	0.36188	0.36206	0.36225
	v	0.022	0.643	1.058	1.472	1.887	1.928	1.970	2.011	2.053	2.063	2.073	2.079	2.084	2.090	2.092	2.094
	d	45.9897	1.5542	0.9453	0.6792	0.5300	0.5186	0.5077	0.4972	0.4872	0.4848	0.4823	0.4809	0.4799	0.4785	0.4780	0.4776
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
310.	P	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125	44.125
	h	115.574	158.114	186.474	214.834	243.194	246.030	248.866	251.702	254.538	255.247	255.956	256.381	256.665	257.090	257.232	257.374
	s	0.17994	0.23521	0.27206	0.30890	0.34575	0.34943	0.35312	0.35680	0.36049	0.36141	0.36233	0.36288	0.36325	0.36380	0.36399	0.36417
	v	0.022	0.573	0.940	1.307	1.675	1.711	1.748	1.785	1.822	1.831	1.840	1.845	1.849	1.855	1.856	1.858
	d	45.5945	1.7457	1.0637	0.7649	0.5971	0.5843	0.5721	0.5603	0.5490	0.5462	0.5435	0.5419	0.5408	0.5392	0.5387	0.5381
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
320.	P	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805	49.805
	h	120.782	162.772	190.765	218.758	246.751	249.550	252.350	255.149	257.948	258.648	259.348	259.768	260.048	260.468	260.608	260.748
	s	0.18663	0.24049	0.27639	0.31229	0.34820	0.35179	0.35538	0.35897	0.36256	0.36346	0.36435	0.36489	0.36525	0.36579	0.36597	0.36615
	v	0.022	0.512	0.838	1.165	1.491	1.524	1.557	1.589	1.622	1.630	1.638	1.643	1.646	1.651	1.653	1.655
	d	45.1943	1.9536	1.1928	0.8584	0.6705	0.6561	0.6424	0.6292	0.6165	0.6134	0.6104	0.6086	0.6074	0.6056	0.6050	0.6044
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
330.	P	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023	56.023
	h	126.036	167.461	195.077	222.693	250.309	253.071	255.832	258.594	261.356	262.046	262.736	263.151	263.427	263.841	263.979	264.117
	s	0.19329	0.24575	0.28072	0.31569	0.35067	0.35416	0.35766	0.36116	0.36465	0.36553	0.36640	0.36693	0.36728	0.36780	0.36798	0.36815
	v	0.022	0.459	0.749	1.040	1.331	1.360	1.389	1.418	1.447	1.455	1.462	1.466	1.469	1.474	1.475	1.476
	d	44.7888	2.1807	1.3344	0.9613	0.7513	0.7352	0.7198	0.7051	0.6909	0.6875	0.6840	0.6820	0.6807	0.6786	0.6780	0.6773
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
340.	P	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812	62.812
	h	131.338	172.188	199.421	226.654	253.887	256.611	259.334	262.057	264.781	265.462	266.142	266.551	266.823	267.232	267.368	267.504
	s	0.19993	0.25101	0.28507	0.31912	0.35318	0.35658	0.35999	0.36339	0.36680	0.36765	0.36850	0.36901	0.36935	0.36986	0.37003	0.37020
	v	0.023	0.412	0.672	0.932	1.192	1.218	1.244	1.270	1.296	1.302	1.309	1.313	1.315	1.319	1.320	1.322
	d	44.3777	2.4257	1.4880	1.0731	0.8391	0.8212	0.8041	0.7876	0.7718	0.7680	0.7642	0.7619	0.7604	0.7582	0.7574	0.7567
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
350.	P	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205	70.205
	h	136.688	176.949	203.790	230.631	257.472	260.156	262.841	265.525	268.209	268.880	269.551	269.953	270.222	270.624	270.759	270.893
	s	0.20654	0.25626	0.28941	0.32256	0.35571	0.35903	0.36234	0.36566	0.36897	0.36980	0.37063	0.37113	0.37146	0.37195	0.37212	0.37229
	v	0.023	0.372	0.604	0.837	1.069	1.093	1.116	1.139	1.162	1.168	1.174	1.178	1.180	1.183	1.185	1.186
	d	43.9603	2.6908	1.6550	1.1950	0.9351	0.9152	0.8961	0.8778	0.8603	0.8560	0.8517	0.8492	0.8475	0.8450	0.8442	0.8434
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
360.	P	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237	78.237
	h	142.086	181.743	208.182	234.620	261.058	263.702	266.346	268.989	271.633	272.294	272.955	273.352	273.616	274.013	274.145	274.277
	s	0.21312	0.26150	0.29375	0.32601	0.35826	0.36149	0.36471	0.36794	0.37116	0.37197	0.37278	0.37326	0.37358	0.37407	0.37423	0.37439
	v	0.023	0.336	0.544	0.753	0.962	0.982	1.003	1.024	1.045	1.050	1.055	1.059	1.061	1.064	1.065	1.066
	d	43.5364	2.9777	1.8369	1.3281	1.0400	1.0179	0.9968	0.9765	0.9570	0.9522	0.9475	0.9447	0.9429	0.9401	0.9392	0.9382
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
370.	P	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909	86.909
	h	147.536	186.574	212.599	238.624	264.650	267.252	269.855	272.457	275.060	275.711	276.361	276.751	277.012	277.402	277.532	277.662
	s	0.21968	0.26674	0.29810	0.32947	0.36084	0.36398	0.36711	0.37025	0.37339	0.37417	0.37495	0.37543	0.37574	0.37621	0.37637	0.37652
	v	0.023	0.304	0.492	0.679	0.867	0.885	0.904	0.923	0.942	0.946	0.951	0.954	0.956	0.959	0.959	0.960
	d	43.1048	3.2856	2.0335	1.4722	1.1538	1.1294	1.1060	1.0835	1.0620	1.0567	1.0515	1.0481	1.0463	1.0433	1.0423	1.0412

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-4, Saturation Thermodynamic Properties of Toluene at Even Increments of Temperature and Quality

Temp																	
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
380.	P	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311	96.311
	h	153.037	191.441	217.043	242.646	268.248	270.808	273.369	275.929	278.489	279.129	279.769	280.153	280.409	280.793	280.921	281.049
	s	0.22622	0.27196	0.30245	0.33294	0.36343	0.36648	0.36953	0.37258	0.37563	0.37639	0.37715	0.37761	0.37792	0.37837	0.37853	0.37868
	v	0.023	0.277	0.445	0.614	0.783	0.800	0.816	0.833	0.850	0.854	0.859	0.861	0.863	0.865	0.866	0.867
	d	42.6656	3.6162	2.2459	1.6287	1.2776	1.2506	1.2248	1.2000	1.1762	1.1704	1.1646	1.1612	1.1589	1.1555	1.1544	1.1533
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
390.	P	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454	106.454
	h	158.591	196.342	221.509	246.676	271.843	274.360	276.877	279.394	281.910	282.539	283.169	283.546	283.798	284.175	284.301	284.427
	s	0.23274	0.27717	0.30679	0.33641	0.36603	0.36899	0.37196	0.37492	0.37788	0.37862	0.37936	0.37981	0.38010	0.38055	0.38069	0.38084
	v	0.024	0.252	0.404	0.556	0.708	0.723	0.738	0.754	0.769	0.773	0.776	0.779	0.780	0.783	0.783	0.784
	d	42.2177	3.9713	2.4760	1.7987	1.4123	1.3827	1.3542	1.3269	1.3006	1.2942	1.2879	1.2841	1.2816	1.2779	1.2766	1.2754
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
400.	P	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377	117.377
	h	164.201	201.280	225.998	250.717	275.436	277.908	280.380	282.852	285.324	285.942	286.560	286.931	287.178	287.548	287.672	287.796
	s	0.23925	0.28238	0.31113	0.33989	0.36864	0.37152	0.37439	0.37727	0.38014	0.38086	0.38158	0.38201	0.38230	0.38273	0.38287	0.38302
	v	0.024	0.230	0.367	0.504	0.642	0.655	0.669	0.683	0.696	0.700	0.703	0.705	0.707	0.709	0.710	0.710
	d	41.7602	4.3513	2.7243	1.9829	1.5587	1.5260	1.4947	1.4647	1.4358	1.4288	1.4218	1.4177	1.4149	1.4108	1.4094	1.4081
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
410.	P	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118	129.118
	h	169.865	206.253	230.511	254.769	279.027	281.453	283.879	286.305	288.730	289.337	289.943	290.307	290.550	290.914	291.035	291.156
	s	0.24574	0.28758	0.31547	0.34336	0.37126	0.37405	0.37683	0.37962	0.38241	0.38311	0.38381	0.38423	0.38450	0.38492	0.38506	0.38520
	v	0.024	0.210	0.334	0.458	0.582	0.595	0.607	0.620	0.632	0.635	0.638	0.640	0.641	0.643	0.644	0.644
	d	41.2858	4.7561	2.9915	2.1820	1.7173	1.6814	1.6471	1.6141	1.5824	1.5747	1.5671	1.5625	1.5595	1.5550	1.5535	1.5520
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
420.	P	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717	141.717
	h	175.588	211.265	235.049	258.834	282.618	284.997	287.375	289.753	292.132	292.726	293.321	293.678	293.916	294.272	294.391	294.510
	s	0.25221	0.29277	0.31981	0.34684	0.37388	0.37658	0.37929	0.38199	0.38469	0.38537	0.38605	0.38645	0.38672	0.38713	0.38726	0.38740
	v	0.025	0.193	0.305	0.417	0.529	0.541	0.552	0.563	0.574	0.577	0.580	0.582	0.583	0.584	0.585	0.586
	d	40.7683	5.1859	3.2784	2.3968	1.8888	1.8496	1.8120	1.7759	1.7412	1.7328	1.7244	1.7194	1.7161	1.7111	1.7095	1.7079
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
430.	P	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168	155.168
	h	181.375	216.309	239.598	262.887	286.176	288.505	290.833	293.162	295.491	296.073	296.656	297.005	297.238	297.587	297.704	297.820
	s	0.25868	0.29795	0.32413	0.35030	0.37648	0.37910	0.38171	0.38433	0.38695	0.38760	0.38826	0.38865	0.38891	0.38931	0.38944	0.38957
	v	0.025	0.177	0.279	0.380	0.482	0.492	0.502	0.512	0.522	0.525	0.527	0.529	0.530	0.531	0.532	0.532
	d	40.2401	5.6469	3.5896	2.6311	2.0766	2.0337	1.9926	1.9531	1.9151	1.9059	1.8967	1.8912	1.8876	1.8822	1.8804	1.8786
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
440.	P	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591	169.591
	h	187.224	221.390	244.167	266.944	289.721	291.999	294.277	296.554	298.832	299.401	299.971	300.312	300.540	300.882	300.996	301.110
	s	0.26514	0.30312	0.32844	0.35375	0.37907	0.38160	0.38413	0.38666	0.38920	0.38983	0.39046	0.39084	0.39109	0.39147	0.39160	0.39173
	v	0.025	0.163	0.255	0.347	0.438	0.448	0.457	0.466	0.475	0.478	0.480	0.481	0.482	0.483	0.484	0.484
	d	39.7010	6.1367	3.9247	2.8848	2.2806	2.2338	2.1889	2.1457	2.1043	2.0942	2.0841	2.0782	2.0742	2.0683	2.0663	2.0644
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
450.	P	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996	184.996
	h	193.141	226.517	248.768	271.018	293.269	295.494	297.719	299.944	302.169	302.725	303.281	303.615	303.838	304.171	304.283	304.394
	s	0.27160	0.30829	0.33275	0.35721	0.38167	0.38412	0.38656	0.38901	0.39145	0.39206	0.39268	0.39304	0.39329	0.39365	0.39378	0.39390
	v	0.026	0.150	0.234	0.317	0.400	0.408	0.417	0.425	0.433	0.435	0.437	0.439	0.440	0.441	0.441	0.442
	d	39.1493	6.6507	4.2813	3.1567	2.5000	2.4491	2.4002	2.3532	2.3080	2.2969	2.2860	2.2795	2.2752	2.2688	2.2666	2.2645

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-4, Saturation Thermodynamic Properties of Toluene at Even Increments of Temperature and Quality

Temp		q 0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
460.	P	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430	201.430
	h	199.130	231.673	253.369	275.064	296.759	298.929	301.099	303.268	305.438	305.980	306.522	306.848	307.065	307.390	307.499	307.607
	s	0.27806	0.31345	0.33704	0.36062	0.38421	0.38657	0.38893	0.39129	0.39365	0.39424	0.39483	0.39518	0.39542	0.39577	0.39589	0.39601
	v	0.026	0.139	0.214	0.289	0.365	0.372	0.380	0.387	0.395	0.397	0.399	0.400	0.400	0.402	0.402	0.402
	d	38.5827	7.2029	4.6705	3.4556	2.7423	2.6868	2.6335	2.5824	2.5331	2.5211	2.5092	2.5021	2.4974	2.4904	2.4880	2.4857
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
470.	P	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884	218.884
	h	205.194	236.876	257.998	279.120	300.242	302.354	304.466	306.578	308.691	309.219	309.747	310.064	310.275	310.592	310.697	310.803
	s	0.28452	0.31860	0.34132	0.36404	0.38676	0.38903	0.39131	0.39358	0.39585	0.39642	0.39699	0.39733	0.39755	0.39789	0.39801	0.39812
	v	0.026	0.129	0.197	0.265	0.333	0.340	0.347	0.353	0.360	0.362	0.364	0.365	0.365	0.366	0.367	0.367
	d	38.0007	7.7796	5.0841	3.7758	3.0030	2.9428	2.8850	2.8293	2.7758	2.7627	2.7498	2.7421	2.7370	2.7293	2.7268	2.7243
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
480.	P	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503	237.503
	h	211.339	242.115	262.633	283.150	303.668	305.719	307.771	309.823	311.875	312.387	312.900	313.208	313.413	313.721	313.824	313.926
	s	0.29100	0.32375	0.34558	0.36742	0.38925	0.39144	0.39362	0.39580	0.39799	0.39853	0.39908	0.39941	0.39962	0.39995	0.40006	0.40017
	v	0.027	0.119	0.181	0.242	0.304	0.310	0.316	0.322	0.329	0.330	0.332	0.333	0.333	0.334	0.334	0.335
	d	37.3997	8.3941	5.5332	4.1267	3.2904	3.2250	3.1622	3.1018	3.0436	3.0294	3.0153	3.0070	3.0014	2.9931	2.9904	2.9876
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
490.	P	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302	257.302
	h	217.576	247.398	267.280	287.162	307.044	309.032	311.020	313.008	314.996	315.493	315.990	316.289	316.487	316.786	316.885	316.984
	s	0.29749	0.32890	0.34983	0.37076	0.39170	0.39379	0.39589	0.39798	0.40007	0.40060	0.40112	0.40143	0.40164	0.40196	0.40206	0.40217
	v	0.027	0.111	0.166	0.222	0.277	0.283	0.288	0.294	0.300	0.301	0.302	0.303	0.304	0.305	0.305	0.305
	d	36.7780	9.0433	6.0178	4.5093	3.6054	3.5346	3.4665	3.4009	3.3378	3.3224	3.3071	3.2981	3.2920	3.2830	3.2800	3.2770
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
500.	P	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272	278.272
	h	223.908	252.730	271.944	291.159	310.373	312.295	314.216	316.138	318.059	318.539	319.020	319.308	319.500	319.788	319.884	319.981
	s	0.30401	0.33404	0.35407	0.37409	0.39411	0.39611	0.39811	0.40012	0.40212	0.40262	0.40312	0.40342	0.40362	0.40392	0.40402	0.40412
	v	0.028	0.103	0.153	0.203	0.253	0.258	0.263	0.268	0.273	0.275	0.276	0.277	0.277	0.278	0.278	0.278
	d	36.1323	9.7218	6.5366	4.9235	3.9490	3.8723	3.7986	3.7276	3.6592	3.6425	3.6260	3.6161	3.6096	3.5998	3.5966	3.5933
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
510.	P	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587	300.587
	h	230.347	258.107	276.614	295.120	313.627	315.477	317.328	319.178	321.029	321.492	321.954	322.232	322.417	322.695	322.787	322.880
	s	0.31056	0.33919	0.35828	0.37736	0.39645	0.39835	0.40026	0.40217	0.40408	0.40456	0.40503	0.40532	0.40551	0.40580	0.40589	0.40599
	v	0.028	0.096	0.141	0.186	0.231	0.236	0.240	0.245	0.249	0.250	0.251	0.252	0.252	0.253	0.253	0.254
	d	35.4588	10.4373	7.0981	5.3777	4.3285	4.2457	4.1660	4.0892	4.0152	3.9971	3.9792	3.9685	3.9614	3.9508	3.9473	3.9438
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
520.	P	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277	324.277
	h	236.917	263.537	281.284	299.030	316.777	318.551	320.326	322.101	323.875	324.319	324.763	325.029	325.206	325.473	325.561	325.650
	s	0.31717	0.34434	0.36246	0.38057	0.39869	0.40050	0.40231	0.40412	0.40593	0.40638	0.40684	0.40711	0.40729	0.40756	0.40765	0.40774
	v	0.029	0.089	0.130	0.170	0.210	0.214	0.219	0.223	0.227	0.228	0.229	0.229	0.230	0.230	0.230	0.231
	d	34.7501	11.1934	7.7093	5.8793	4.7515	4.6620	4.5759	4.4929	4.4128	4.3933	4.3739	4.3623	4.3547	4.3432	4.3394	4.3356
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
530.	P	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309	349.309
	h	243.614	269.014	285.948	302.882	319.815	321.509	323.202	324.896	326.589	327.012	327.436	327.690	327.859	328.113	328.198	328.282
	s	0.32383	0.34950	0.36661	0.38372	0.40083	0.40254	0.40425	0.40596	0.40767	0.40810	0.40853	0.40878	0.40895	0.40921	0.40930	0.40938
	v	0.029	0.083	0.119	0.155	0.192	0.195	0.199	0.202	0.206	0.207	0.208	0.208	0.209	0.209	0.209	0.210
	d	34.0083	11.9847	8.3700	6.4314	5.2216	5.1252	5.0323	4.9427	4.8563	4.8351	4.8141	4.8017	4.7934	4.7810	4.7769	4.7728

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-4, Saturation Thermodynamic Properties of Toluene at Even Increments of Temperature and Quality

Temp																	
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
540.	P	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864	375.864
	h	250.490	274.564	290.613	306.662	322.711	324.316	325.921	327.526	329.131	329.532	329.933	330.174	330.334	330.575	330.655	330.736
	s	0.33060	0.35468	0.37073	0.38678	0.40284	0.40444	0.40605	0.40765	0.40926	0.40966	0.41006	0.41030	0.41046	0.41070	0.41078	0.41086
	v	0.030	0.078	0.110	0.142	0.174	0.177	0.180	0.183	0.187	0.187	0.188	0.189	0.189	0.190	0.190	0.190
	d	33.2138	12.8161	9.0932	7.0463	5.7516	5.6478	5.5477	5.4511	5.3578	5.3350	5.3124	5.2989	5.2899	5.2765	5.2721	5.2677
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
550.	P	404.035	404.035	404.035	404.035	404.034	404.034	404.034	404.034	404.034	404.034	404.034	404.034	404.034	404.034	404.034	404.034
	h	257.581	280.186	295.256	310.325	325.395	326.902	328.409	329.916	331.423	331.800	332.176	332.402	332.553	332.779	332.855	332.930
	s	0.33749	0.35988	0.37480	0.38973	0.40465	0.40615	0.40764	0.40913	0.41062	0.41100	0.41137	0.41159	0.41174	0.41197	0.41204	0.41212
	v	0.031	0.073	0.101	0.129	0.157	0.160	0.163	0.166	0.169	0.169	0.170	0.170	0.171	0.171	0.171	0.171
	d	32.3562	13.6932	9.8901	7.7404	6.3583	6.2468	6.1391	6.0350	5.9345	5.9098	5.8854	5.8709	5.8612	5.8468	5.8420	5.8372
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
560.	P	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944	433.944
	h	264.937	285.901	299.877	313.853	327.829	329.227	330.625	332.022	333.420	333.769	334.119	334.328	334.468	334.678	334.748	334.818
	s	0.34456	0.36512	0.37883	0.39254	0.40624	0.40761	0.40898	0.41035	0.41172	0.41207	0.41241	0.41261	0.41275	0.41296	0.41303	0.41309
	v	0.032	0.068	0.093	0.117	0.142	0.144	0.147	0.149	0.151	0.152	0.153	0.153	0.153	0.154	0.154	0.154
	d	31.4242	14.6128	10.7712	8.5290	7.0595	6.9399	6.8243	6.7125	6.6043	6.5778	6.5515	6.5358	6.5254	6.5099	6.5047	6.4995
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
570.	P	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661	465.661
	h	272.655	291.719	304.429	317.139	329.849	331.120	332.391	333.662	334.933	335.251	335.568	335.759	335.886	336.077	336.140	336.204
	s	0.35191	0.37042	0.38276	0.39511	0.40745	0.40868	0.40992	0.41115	0.41239	0.41270	0.41300	0.41319	0.41331	0.41350	0.41356	0.41362
	v	0.033	0.064	0.085	0.106	0.127	0.129	0.131	0.133	0.135	0.135	0.136	0.136	0.136	0.137	0.137	0.137
	d	30.3883	15.5945	11.7734	9.4564	7.9013	7.7735	7.6498	7.5299	7.4137	7.3852	7.3569	7.3401	7.3289	7.3122	7.3066	7.3010
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
580.	P	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144	500.144
	h	280.895	297.647	308.816	319.985	331.153	332.270	333.387	334.504	335.621	335.900	336.179	336.347	336.458	336.626	336.682	336.738
	s	0.35966	0.37576	0.38650	0.39724	0.40798	0.40906	0.41013	0.41121	0.41228	0.41255	0.41282	0.41298	0.41309	0.41325	0.41330	0.41335
	v	0.034	0.060	0.077	0.094	0.111	0.113	0.115	0.117	0.118	0.119	0.119	0.119	0.120	0.120	0.120	0.120
	d	29.2036	16.6798	12.9713	10.6120	8.9788	8.8427	8.7107	8.5825	8.4581	8.4276	8.3973	8.3792	8.3671	8.3492	8.3432	8.3373
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
590.	P	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579	535.579
	h	290.279	304.077	313.275	322.473	331.671	332.591	333.511	334.431	335.350	335.580	335.810	335.948	336.040	336.178	336.224	336.270
	s	0.36841	0.38155	0.39031	0.39908	0.40784	0.40871	0.40959	0.41047	0.41134	0.41156	0.41178	0.41191	0.41200	0.41213	0.41218	0.41222
	v	0.036	0.056	0.070	0.083	0.097	0.098	0.099	0.101	0.102	0.102	0.103	0.103	0.103	0.103	0.103	0.103
	d	27.6634	17.7717	14.3508	12.0343	10.3617	10.2196	10.0814	9.9469	9.8159	9.7837	9.7518	9.7327	9.7200	9.7010	9.6947	9.6884
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
600.	P	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513	575.513
	h	302.774	310.745	316.060	321.374	326.688	327.220	327.751	328.283	328.814	328.947	329.080	329.160	329.213	329.292	329.319	329.346
	s	0.37997	0.38749	0.39250	0.39751	0.40253	0.40303	0.40353	0.40403	0.40453	0.40466	0.40478	0.40486	0.40491	0.40498	0.40501	0.40503
	v	0.040	0.051	0.059	0.066	0.073	0.074	0.075	0.075	0.076	0.076	0.077	0.077	0.077	0.077	0.077	0.077
	d	24.8162	19.5000	17.0632	15.1677	13.6512	13.5161	13.3836	13.2537	13.1263	13.0948	13.0635	13.0448	13.0323	13.0137	13.0075	13.0013

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
60.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	-0.032	-0.025	-0.014	0.009	0.078	0.193	0.423	0.653	0.883	1.115	1.346	1.577	1.808	2.040	2.272	2.739
	s	0.00002	0.00002	0.00001	-0.00002	-0.00009	-0.00020	-0.00043	-0.00066	-0.00088	-0.00111	-0.00133	-0.00156	-0.00178	-0.00200	-0.00222	-0.00266
	v	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	d	54.5019	54.5029	54.5044	54.5076	54.5172	54.5329	54.5643	54.5957	54.6269	54.6576	54.6882	54.7189	54.7493	54.7793	54.8094	54.8685
70.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	4.020	4.027	4.037	4.060	4.129	4.242	4.471	4.699	4.928	5.157	5.387	5.616	5.847	6.077	6.308	6.770
	s	0.00775	0.00774	0.00773	0.00770	0.00763	0.00752	0.00729	0.00705	0.00683	0.00660	0.00637	0.00614	0.00592	0.00569	0.00547	0.00503
	v	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	d	54.1760	54.1770	54.1789	54.1821	54.1920	54.2086	54.2412	54.2738	54.3061	54.3383	54.3702	54.4020	54.4335	54.4648	54.4960	54.5577
80.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	8.125	8.132	8.143	8.166	8.234	8.346	8.572	8.800	9.027	9.254	9.481	9.711	9.939	10.168	10.396	10.856
	s	0.01542	0.01542	0.01541	0.01538	0.01531	0.01519	0.01496	0.01472	0.01449	0.01426	0.01403	0.01380	0.01357	0.01334	0.01312	0.01267
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.018
	d	53.8481	53.8492	53.8509	53.8543	53.8646	53.8819	53.9161	53.9499	53.9834	54.0170	54.0503	54.0830	54.1159	54.1485	54.1809	54.2449
90.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	12.284	12.291	12.302	12.324	12.391	12.503	12.728	12.953	13.178	13.404	13.630	13.856	14.083	14.310	14.537	14.994
	s	0.02306	0.02305	0.02304	0.02302	0.02294	0.02282	0.02259	0.02235	0.02211	0.02188	0.02164	0.02141	0.02118	0.02095	0.02072	0.02027
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	53.5178	53.5189	53.5207	53.5244	53.5351	53.5530	53.5886	53.6238	53.6589	53.6937	53.7281	53.7624	53.7966	53.8303	53.8640	53.9304
100.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	16.494	16.501	16.512	16.534	16.600	16.711	16.934	17.157	17.381	17.605	17.828	18.053	18.279	18.503	18.730	19.183
	s	0.03065	0.03064	0.03063	0.03061	0.03053	0.03041	0.03017	0.02993	0.02969	0.02945	0.02921	0.02898	0.02874	0.02851	0.02828	0.02782
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	53.1854	53.1864	53.1883	53.1920	53.2033	53.2220	53.2590	53.2957	53.3320	53.3682	53.4043	53.4398	53.4752	53.5106	53.5454	53.6144
110.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	20.755	20.761	20.772	20.794	20.860	20.970	21.191	21.411	21.633	21.855	22.077	22.300	22.524	22.747	22.972	23.421
	s	0.03820	0.03819	0.03817	0.03815	0.03808	0.03795	0.03771	0.03746	0.03722	0.03698	0.03674	0.03650	0.03626	0.03602	0.03579	0.03532
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	52.8506	52.8520	52.8540	52.8578	52.8694	52.8888	52.9273	52.9656	53.0035	53.0411	53.0784	53.1156	53.1522	53.1889	53.2250	53.2967
120.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	25.064	25.071	25.082	25.103	25.169	25.278	25.495	25.715	25.934	26.154	26.374	26.596	26.817	27.039	27.262	27.708
	s	0.04570	0.04569	0.04568	0.04565	0.04557	0.04545	0.04520	0.04495	0.04471	0.04446	0.04422	0.04397	0.04373	0.04349	0.04326	0.04278
	v	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	52.5138	52.5149	52.5168	52.5211	52.5332	52.5535	52.5937	52.6334	52.6728	52.7120	52.7510	52.7893	52.8276	52.8657	52.9032	52.9775
130.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	200.503	29.429	29.439	29.461	29.525	29.633	29.850	30.066	30.283	30.501	30.720	30.938	31.157	31.378	31.598	32.041
	s	0.30147	0.05314	0.05313	0.05310	0.05303	0.05290	0.05265	0.05239	0.05214	0.05189	0.05165	0.05140	0.05116	0.05091	0.05067	0.05019
	v	11.534	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0867	52.1758	52.1780	52.1821	52.1950	52.2160	52.2576	52.2993	52.3403	52.3810	52.4214	52.4615	52.5014	52.5406	52.5798	52.6569
140.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	203.524	33.834	33.845	33.866	33.929	34.036	34.250	34.464	34.679	34.895	35.110	35.328	35.545	35.763	35.981	36.420
	s	0.30655	0.06055	0.06054	0.06051	0.06043	0.06030	0.06005	0.05979	0.05954	0.05928	0.05903	0.05878	0.05853	0.05829	0.05804	0.05756
	v	11.601	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0862	51.8345	51.8366	51.8410	51.8544	51.8762	51.9196	51.9630	52.0058	52.0480	52.0903	52.1318	52.1732	52.2140	52.2547	52.3350

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
150.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	206.595	38.285	38.296	38.316	38.380	38.485	38.696	38.908	39.120	39.334	39.548	39.763	39.978	40.193	40.411	40.845
	s	0.31163	0.06791	0.06790	0.06787	0.06779	0.06766	0.06740	0.06714	0.06688	0.06662	0.06637	0.06612	0.06587	0.06562	0.06537	0.06488
	v	11.670	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0857	51.4908	51.4931	51.4979	51.5113	51.5344	51.5797	51.6248	51.6693	51.7134	51.7572	51.8004	51.8434	51.8859	51.9279	52.0112
160.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	209.369	42.783	42.792	42.814	42.876	42.979	43.188	43.397	43.608	43.818	44.030	44.242	44.455	44.669	44.883	45.314
	s	0.35928	0.07523	0.07521	0.07519	0.07511	0.07497	0.07471	0.07444	0.07418	0.07392	0.07366	0.07341	0.07315	0.07290	0.07264	0.07215
	v	35.790	0.020	0.020	0.020	0.020	0.020	0.020	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
	d	0.0279	51.1445	51.1473	51.1518	51.1662	51.1902	51.2375	51.2845	51.3307	51.3767	51.4221	51.4671	51.5119	51.5561	51.6000	51.6863
170.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	212.552	212.884	47.335	47.355	47.417	47.520	47.725	47.931	48.138	48.347	48.556	48.765	48.976	49.187	49.399	49.825
	s	0.36437	0.32177	0.08248	0.08246	0.08238	0.08224	0.08197	0.08170	0.08143	0.08117	0.08091	0.08065	0.08039	0.08013	0.07987	0.07937
	v	36.384	14.558	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.019
	d	0.0275	0.0687	50.7987	50.8038	50.8186	50.8435	50.8928	50.9418	50.9902	51.0379	51.0852	51.1322	51.1786	51.2247	51.2701	51.3598
180.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	215.782	216.101	51.921	51.942	52.002	52.104	52.306	52.509	52.714	52.919	53.125	53.332	53.541	53.749	53.959	54.380
	s	0.36946	0.32684	0.08971	0.08968	0.08960	0.08946	0.08919	0.08891	0.08864	0.08837	0.08811	0.08784	0.08758	0.08732	0.08706	0.08654
	v	36.975	14.795	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0270	0.0676	50.4479	50.4530	50.4686	50.4945	50.5460	50.5970	50.6474	50.6972	50.7466	50.7954	50.8434	50.8913	50.9385	51.0319
190.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	219.059	218.591	56.553	56.572	56.631	56.731	56.931	57.131	57.332	57.535	57.737	57.943	58.148	58.353	58.560	58.977
	s	0.37455	0.35429	0.09690	0.09687	0.09678	0.09664	0.09636	0.09608	0.09581	0.09553	0.09526	0.09499	0.09473	0.09446	0.09420	0.09368
	v	37.565	14.878	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0266	0.0672	50.0942	50.0997	50.1162	50.1431	50.1967	50.2498	50.3026	50.3543	50.4058	50.4562	50.5066	50.5564	50.6055	50.7022
200.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	222.384	221.935	61.226	61.246	61.304	61.402	61.597	61.795	61.993	62.193	62.394	62.595	62.797	63.	63.204	63.615
	s	0.37962	0.35940	0.10403	0.10401	0.10392	0.10378	0.10349	0.10321	0.10293	0.10265	0.10237	0.10210	0.10183	0.10156	0.10129	0.10076
	v	38.157	15.121	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0262	0.0661	49.7382	49.7437	49.7609	49.7892	49.8454	49.9005	49.9553	50.0091	50.0625	50.1153	50.1677	50.2194	50.2706	50.3713
210.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	225.756	225.323	226.041	65.963	66.021	66.117	66.309	66.502	66.697	66.893	67.091	67.288	67.488	67.688	67.890	68.296
	s	0.38470	0.36450	0.34203	0.11110	0.11102	0.11087	0.11058	0.11029	0.11000	0.10972	0.10944	0.10916	0.10889	0.10861	0.10834	0.10780
	v	38.748	15.362	7.683	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0258	0.0651	0.1302	49.3850	49.4025	49.4321	49.4908	49.5485	49.6056	49.6619	49.7175	49.7727	49.8268	49.8807	49.9338	50.0383
220.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	229.174	228.757	229.449	70.725	70.780	70.874	71.062	71.253	71.443	71.637	71.830	72.025	72.220	72.418	72.617	73.017
	s	0.38976	0.36959	0.34708	0.11816	0.11807	0.11792	0.11762	0.11733	0.11704	0.11675	0.11647	0.11618	0.11590	0.11562	0.11535	0.11480
	v	39.338	15.602	7.803	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0254	0.0641	0.1281	49.0228	49.0415	49.0724	49.1335	49.1937	49.2534	49.3118	49.3700	49.4272	49.4842	49.5399	49.5952	49.7038
230.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	232.639	232.236	231.553	75.528	75.582	75.675	75.859	76.045	76.233	76.421	76.612	76.802	76.995	77.189	77.384	77.778
	s	0.39482	0.37467	0.35903	0.12518	0.12508	0.12493	0.12463	0.12433	0.12403	0.12374	0.12345	0.12316	0.12287	0.12259	0.12231	0.12175
	v	39.928	15.843	7.813	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	0.0250	0.0631	0.1260	48.6577	48.6774	48.7093	48.7734	48.8364	48.8983	48.9598	49.0201	49.0799	49.1388	49.1971	49.2545	49.3675

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
240.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	236.149	235.761	235.102	80.376	80.429	80.519	80.698	80.880	81.062	81.248	81.434	81.621	81.809	81.999	82.191	82.578
	s	0.39988	0.37974	0.36414	0.13216	0.13206	0.13191	0.13160	0.13129	0.13099	0.13069	0.13039	0.13010	0.12980	0.12951	0.12923	0.12866
	v	40.517	16.083	7.936	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.020	0.020	0.020	0.020
	d	0.0247	0.0622	0.1260	48.2889	48.3095	48.3432	48.4099	48.4760	48.5409	48.6047	48.6678	48.7301	48.7918	48.8525	48.9121	49.0296
250.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	239.705	239.330	238.695	85.266	85.318	85.405	85.580	85.756	85.935	86.116	86.297	86.481	86.666	86.852	87.040	87.421
	s	0.40492	0.38481	0.36924	0.13910	0.13900	0.13884	0.13852	0.13821	0.13790	0.13760	0.13729	0.13699	0.13670	0.13640	0.13611	0.13554
	v	41.106	16.322	8.060	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0243	0.0613	0.1241	47.9167	47.9380	47.9735	48.0435	48.1125	48.1802	48.2470	48.3130	48.3778	48.4419	48.5050	48.5673	48.6891
260.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	243.305	242.944	242.332	243.545	90.251	90.334	90.505	90.676	90.849	91.025	91.203	91.382	91.563	91.745	91.929	92.301
	s	0.40996	0.38986	0.37432	0.36722	0.14590	0.14574	0.14541	0.14510	0.14478	0.14447	0.14416	0.14385	0.14355	0.14325	0.14295	0.14236
	v	41.693	16.562	8.184	4.093	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0240	0.0604	0.1222	0.2443	47.5625	47.6001	47.6733	47.7453	47.8165	47.8864	47.9549	48.0227	48.0894	48.1552	48.2201	48.3475
270.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	246.952	246.603	246.011	244.788	95.225	95.307	95.472	95.637	95.805	95.976	96.148	96.323	96.500	96.678	96.858	97.222
	s	0.41499	0.39491	0.37940	0.36327	0.15277	0.15260	0.15227	0.15194	0.15162	0.15130	0.15098	0.15067	0.15036	0.15006	0.14975	0.14916
	v	42.282	16.801	8.307	4.056	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0237	0.0595	0.1204	0.2466	47.1840	47.2225	47.2991	47.3752	47.4494	47.5224	47.5944	47.6650	47.7345	47.8031	47.8708	48.0033
280.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	250.643	250.305	249.734	248.554	100.246	100.323	100.481	100.641	100.804	100.970	101.137	101.307	101.477	101.650	101.827	102.183
	s	0.42002	0.39995	0.38447	0.36839	0.15960	0.15943	0.15909	0.15875	0.15842	0.15810	0.15777	0.15745	0.15714	0.15682	0.15652	0.15591
	v	42.870	17.040	8.429	4.121	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0233	0.0587	0.1186	0.2427	46.8000	46.8411	46.9217	47.0008	47.0787	47.1549	47.2302	47.3040	47.3769	47.4486	47.5188	47.6566
290.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	254.378	254.051	253.498	252.359	105.310	105.384	105.535	105.689	105.845	106.005	106.167	106.330	106.498	106.667	106.835	107.182
	s	0.42503	0.40498	0.38952	0.37351	0.16640	0.16622	0.16587	0.16553	0.16519	0.16486	0.16453	0.16420	0.16388	0.16356	0.16324	0.16262
	v	43.459	17.278	8.551	4.185	0.022	0.022	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021
	d	0.0230	0.0579	0.1169	0.2390	46.4113	46.4543	46.5392	46.6223	46.7040	46.7841	46.8626	46.9401	47.0158	47.0903	47.1643	47.3079
300.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	258.156	257.840	257.305	256.206	110.418	110.488	110.633	110.779	110.929	111.083	111.239	111.396	111.557	111.720	111.886	112.223
	s	0.43004	0.41000	0.39457	0.37860	0.17317	0.17299	0.17263	0.17228	0.17193	0.17159	0.17125	0.17091	0.17058	0.17026	0.16994	0.16930
	v	44.044	17.517	8.673	4.249	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.021	0.021	0.021	0.021	0.021
	d	0.0227	0.0571	0.1153	0.2354	46.0177	46.0633	46.1522	46.2397	46.3254	46.4089	46.4914	46.5726	46.6520	46.7300	46.8064	46.9564
310.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	261.980	261.673	261.155	260.093	115.571	115.638	115.775	115.914	116.055	116.202	116.352	116.504	116.657	116.816	116.976	117.302
	s	0.43504	0.41502	0.39960	0.38369	0.17991	0.17972	0.17935	0.17899	0.17863	0.17828	0.17793	0.17759	0.17725	0.17692	0.17659	0.17594
	v	44.633	17.755	8.795	4.313	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.021
	d	0.0224	0.0563	0.1137	0.2319	45.6186	45.6664	45.7602	45.8521	45.9426	46.0305	46.1165	46.2011	46.2848	46.3659	46.4461	46.6023
320.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	265.845	265.548	265.047	264.020	120.772	120.834	120.961	121.091	121.228	121.365	121.507	121.653	121.801	121.952	122.106	122.422
	s	0.44003	0.42002	0.40463	0.38875	0.18662	0.18643	0.18605	0.18567	0.18531	0.18494	0.18459	0.18424	0.18389	0.18355	0.18321	0.18255
	v	45.218	17.993	8.916	4.376	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0221	0.0556	0.1122	0.2285	45.2134	45.2639	45.3629	45.4600	45.5540	45.6471	45.7374	45.8261	45.9133	45.9987	46.0823	46.2450

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
330.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	269.754	269.466	268.980	267.986	264.788	126.075	126.193	126.315	126.441	126.573	126.706	126.844	126.987	127.129	127.278	127.581
	s	0.44501	0.42501	0.40964	0.39381	0.37114	0.19311	0.19272	0.19233	0.19195	0.19158	0.19121	0.19085	0.19050	0.19015	0.18980	0.18913
	v	45.805	18.230	9.038	4.439	1.674	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0218	0.0549	0.1106	0.2253	0.5972	44.8550	44.9598	45.0618	45.1614	45.2585	45.3540	45.4470	45.5376	45.6277	45.7148	45.8853
340.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	273.706	273.426	272.955	271.992	268.907	131.365	131.473	131.584	131.702	131.824	131.949	132.078	132.212	132.350	132.489	132.781
	s	0.44998	0.42999	0.41464	0.39885	0.37632	0.19976	0.19936	0.19896	0.19857	0.19819	0.19781	0.19744	0.19708	0.19672	0.19636	0.19567
	v	46.393	18.467	9.158	4.502	1.703	0.023	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0216	0.0541	0.1092	0.2221	0.5872	44.4392	44.5496	44.6577	44.7627	44.8649	44.9653	45.0633	45.1589	45.2521	45.3442	45.5216
350.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	277.700	277.428	276.972	276.039	273.060	136.705	136.799	136.900	137.008	137.119	137.235	137.354	137.483	137.611	137.745	138.022
	s	0.45495	0.43497	0.41963	0.40388	0.38148	0.20640	0.20598	0.20557	0.20517	0.20477	0.20438	0.20400	0.20363	0.20326	0.20289	0.20218
	v	46.979	18.704	9.280	4.565	1.732	0.023	0.023	0.023	0.023	0.022	0.022	0.022	0.022	0.022	0.022	0.022
	d	0.0213	0.0535	0.1078	0.2190	0.5775	44.0151	44.1329	44.2472	44.3578	44.4661	44.5717	44.6750	44.7743	44.8731	44.9689	45.1548
360.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	281.736	281.473	281.029	280.125	277.246	142.092	142.175	142.263	142.359	142.461	142.565	142.678	142.794	142.915	143.039	143.302
	s	0.45990	0.43993	0.42461	0.40889	0.38662	0.21301	0.21258	0.21215	0.21174	0.21133	0.21092	0.21053	0.21015	0.20977	0.20939	0.20867
	v	47.564	18.942	9.400	4.628	1.760	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.022	0.022	0.022
	d	0.0210	0.0528	0.1064	0.2161	0.5683	43.5836	43.7080	43.8296	43.9469	44.0608	44.1724	44.2805	44.3863	44.4890	44.5903	44.7845
370.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	285.814	285.558	285.127	284.250	281.467	147.531	147.600	147.674	147.758	147.849	147.943	148.044	148.152	148.263	148.377	148.624
	s	0.46485	0.44489	0.42958	0.41390	0.39174	0.21961	0.21916	0.21871	0.21828	0.21786	0.21745	0.21704	0.21664	0.21625	0.21587	0.21512
	v	48.152	19.179	9.520	4.690	1.788	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	d	0.0208	0.0521	0.1050	0.2132	0.5593	43.1431	43.2754	43.4044	43.5285	43.6491	43.7668	43.8809	43.9919	44.1001	44.2065	44.4101
380.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	289.933	289.685	289.266	288.414	285.720	153.025	153.078	153.138	153.205	153.283	153.365	153.456	153.551	153.654	153.759	153.989
	s	0.46978	0.44983	0.43454	0.41889	0.39683	0.22619	0.22572	0.22526	0.22481	0.22437	0.22394	0.22352	0.22311	0.22271	0.22231	0.22155
	v	48.736	19.415	9.641	4.753	1.816	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	d	0.0205	0.0515	0.1037	0.2104	0.5508	42.6919	42.8328	42.9702	43.1030	43.2304	43.3549	43.4752	43.5925	43.7061	43.8175	44.0311
390.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	294.093	293.851	293.444	292.618	290.010	285.106	158.607	158.651	158.705	158.766	158.839	158.913	158.998	159.088	159.184	159.395
	s	0.47471	0.45476	0.43949	0.42386	0.40191	0.38272	0.23227	0.23179	0.23132	0.23086	0.23042	0.22998	0.22956	0.22914	0.22874	0.22795
	v	49.322	19.652	9.761	4.815	1.843	0.845	0.024	0.024	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
	d	0.0203	0.0509	0.1025	0.2077	0.5425	1.1840	42.3814	42.5274	42.6681	42.8041	42.9347	43.0630	43.1865	43.3069	43.4239	43.6481
400.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	298.294	298.059	297.664	296.860	294.332	289.616	164.194	164.221	164.257	164.302	164.357	164.421	164.491	164.570	164.655	164.843
	s	0.47962	0.45969	0.44443	0.42883	0.40697	0.38799	0.23880	0.23830	0.23782	0.23734	0.23688	0.23643	0.23599	0.23556	0.23514	0.23432
	v	49.908	19.888	9.861	4.877	1.870	0.861	0.024	0.024	0.024	0.024	0.024	0.023	0.023	0.023	0.023	0.023
	d	0.0200	0.0503	0.1012	0.2051	0.5346	1.1611	41.9170	42.0732	42.2232	42.3684	42.5081	42.6431	42.7741	42.9008	43.0240	43.2601
410.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	302.536	302.307	301.923	301.141	298.690	294.147	169.844	169.846	169.861	169.890	169.926	169.976	170.032	170.099	170.171	170.335
	s	0.48453	0.46460	0.44935	0.43378	0.41201	0.39323	0.24534	0.24481	0.24430	0.24380	0.24332	0.24285	0.24240	0.24195	0.24152	0.24067
	v	50.493	20.125	10.001	4.938	1.898	0.878	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.023	0.023
	d	0.0198	0.0497	0.1000	0.2025	0.5270	1.1395	41.4338	41.6040	41.7662	41.9210	42.0709	42.2137	42.3528	42.4865	42.6165	42.8659

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5. Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
420.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	306.818	306.595	306.221	305.461	303.083	298.701	175.553	175.529	175.524	175.531	175.550	175.580	175.623	175.673	175.729	175.872
	s	0.48942	0.46950	0.45427	0.43872	0.41703	0.39844	0.25186	0.25131	0.25077	0.25025	0.24975	0.24926	0.24879	0.24832	0.24787	0.24700
	v	51.080	20.361	10.121	5.	1.925	0.894	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	d	0.0196	0.0491	0.0988	0.2000	0.5196	1.1191	40.9136	41.1068	41.2851	41.4538	41.6149	41.7694	41.9170	42.0601	42.1988	42.4616
430.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	311.139	310.922	310.558	309.819	307.510	303.280	181.326	181.276	181.245	181.230	181.226	181.239	181.264	181.296	181.342	181.453
	s	0.49431	0.47439	0.45917	0.44364	0.42204	0.40362	0.25839	0.25780	0.25724	0.25669	0.25616	0.25566	0.25516	0.25468	0.25422	0.25331
	v	51.664	20.597	10.240	5.062	1.951	0.909	0.025	0.025	0.025	0.024	0.024	0.024	0.024	0.024	0.024	0.024
	d	0.0194	0.0486	0.0977	0.1976	0.5124	1.0996	40.3741	40.5915	40.7886	40.9725	41.1479	41.3132	41.4716	41.6249	41.7707	42.0506
440.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	315.499	315.288	314.933	314.214	311.971	307.885	187.172	187.088	187.029	186.988	186.964	186.952	186.954	186.971	186.998	187.080
	s	0.49918	0.47927	0.46406	0.44855	0.42702	0.40876	0.26492	0.26430	0.26370	0.26313	0.26258	0.26204	0.26152	0.26102	0.26054	0.25960
	v	52.248	20.833	10.360	5.123	1.978	0.925	0.025	0.025	0.025	0.025	0.025	0.024	0.024	0.024	0.024	0.024
	d	0.0191	0.0480	0.0965	0.1952	0.5055	1.0810	39.8110	40.0582	40.2756	40.4769	40.6657	40.8455	41.0159	41.1788	41.3357	41.6319
450.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	319.899	319.693	319.348	318.649	316.468	312.516	193.096	192.974	192.879	192.806	192.753	192.719	192.702	192.695	192.706	192.756
	s	0.50405	0.48414	0.46894	0.45346	0.43199	0.41388	0.27147	0.27080	0.27017	0.26956	0.26898	0.26842	0.26788	0.26735	0.26685	0.26588
	v	52.834	21.068	10.479	5.184	2.005	0.941	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.024	0.024
	d	0.0189	0.0475	0.0954	0.1929	0.4988	1.0632	39.2226	39.5016	39.7444	39.9655	40.1715	40.3652	40.5481	40.7239	40.8903	41.2052
460.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	324.338	324.137	323.801	323.119	321.	317.173	324.471	198.939	198.804	198.694	198.611	198.546	198.507	198.479	198.465	198.480
	s	0.50890	0.48900	0.47381	0.45834	0.43695	0.41897	0.46603	0.27733	0.27665	0.27600	0.27538	0.27479	0.27422	0.27368	0.27314	0.27213
	v	53.419	21.304	10.598	5.245	2.031	0.956	0.477	0.026	0.026	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	d	0.0187	0.0469	0.0944	0.1907	0.4923	1.0463	2.0944	38.9209	39.1909	39.4349	39.6599	39.8706	40.0672	40.2551	40.4345	40.7694
470.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	328.815	328.619	328.292	327.627	325.565	321.858	312.853	204.987	204.802	204.651	204.533	204.440	204.368	204.316	204.278	204.249
	s	0.51374	0.49385	0.47866	0.46322	0.44189	0.42404	0.40174	0.28387	0.28313	0.28244	0.28179	0.28116	0.28056	0.27999	0.27943	0.27837
	v	54.003	21.539	10.718	5.306	2.057	0.971	0.417	0.026	0.026	0.026	0.026	0.025	0.025	0.025	0.025	0.025
	d	0.0185	0.0464	0.0933	0.1885	0.4860	1.0301	2.4007	38.3125	38.6154	38.8848	39.1305	39.3589	39.5731	39.7748	39.9675	40.3258
480.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	333.330	333.140	332.820	332.173	330.167	326.572	317.961	211.131	210.889	210.690	210.526	210.397	210.291	210.207	210.147	210.077
	s	0.51857	0.49868	0.48351	0.46808	0.44681	0.42908	0.40721	0.29044	0.28965	0.28890	0.28820	0.28753	0.28690	0.28629	0.28571	0.28461
	v	54.585	21.775	10.837	5.367	2.084	0.986	0.427	0.027	0.026	0.026	0.026	0.026	0.026	0.025	0.025	0.025
	d	0.0183	0.0459	0.0923	0.1863	0.4799	1.0145	2.3417	37.6725	38.0111	38.3099	38.5816	38.8306	39.0634	39.2825	39.4880	39.8698
490.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	337.884	337.698	337.385	336.754	334.801	331.314	323.060	217.387	217.072	216.812	216.603	216.424	216.283	216.167	216.075	215.954
	s	0.52339	0.50351	0.48834	0.47293	0.45171	0.43410	0.41261	0.29706	0.29619	0.29538	0.29463	0.29392	0.29324	0.29260	0.29199	0.29083
	v	55.171	22.010	10.955	5.428	2.110	1.	0.437	0.027	0.027	0.027	0.026	0.026	0.026	0.026	0.026	0.025
	d	0.0181	0.0454	0.0913	0.1842	0.4740	0.9995	2.2874	36.9937	37.3766	37.7098	38.0083	38.2830	38.5359	38.7723	38.9949	39.4044
500.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	342.476	342.292	341.989	341.372	339.470	336.085	328.160	223.773	223.358	223.033	222.757	222.535	222.345	222.194	222.066	221.883
	s	0.52820	0.50832	0.49316	0.47777	0.45660	0.43910	0.41795	0.30375	0.30278	0.30190	0.30108	0.30032	0.29959	0.29891	0.29826	0.29704
	v	55.758	22.244	11.074	5.489	2.136	1.015	0.447	0.028	0.027	0.027	0.027	0.027	0.026	0.026	0.026	0.026
	d	0.0179	0.0450	0.0903	0.1822	0.4682	0.9851	2.2369	36.2688	36.7064	37.0777	37.4116	37.7113	37.9892	38.2454	38.4866	38.9278

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
510.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	347.103	346.926	346.628	346.028	344.173	340.884	333.261	347.221	229.784	229.355	229.009	228.722	228.484	228.284	228.121	227.874
	s	0.53300	0.51313	0.49797	0.48260	0.46148	0.44408	0.42324	0.49011	0.30944	0.30845	0.30756	0.30673	0.30596	0.30523	0.30454	0.30325
	v	56.340	22.480	11.193	5.549	2.162	1.030	0.457	0.304	0.028	0.027	0.027	0.027	0.027	0.027	0.026	0.026
	d	0.0177	0.0445	0.0893	0.1802	0.4626	0.9713	2.1899	3.2872	35.9881	36.4123	36.7842	37.1173	37.4212	37.7020	37.9626	38.4369
520.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	351.769	351.595	351.305	350.719	348.911	345.713	338.370	328.671	236.354	235.809	235.370	235.005	234.704	234.456	234.247	233.923
	s	0.53779	0.51792	0.50277	0.48741	0.46634	0.44903	0.42848	0.41191	0.31618	0.31507	0.31408	0.31318	0.31234	0.31156	0.31082	0.30946
	v	56.926	22.716	11.312	5.610	2.187	1.044	0.466	0.263	0.028	0.028	0.028	0.027	0.027	0.027	0.027	0.026
	d	0.0176	0.0440	0.0884	0.1782	0.4572	0.9579	2.1459	3.7992	35.2178	35.7029	36.1208	36.4938	36.8296	37.1358	37.4197	37.9329
530.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	356.470	356.302	356.018	355.445	353.682	350.572	343.489	334.368	243.117	242.413	241.851	241.394	241.018	240.708	240.443	240.039
	s	0.54256	0.52270	0.50756	0.49221	0.47119	0.45397	0.43368	0.41770	0.32305	0.32178	0.32067	0.31966	0.31875	0.31791	0.31711	0.31567
	v	57.509	22.951	11.431	5.670	2.213	1.058	0.475	0.272	0.029	0.029	0.028	0.028	0.028	0.027	0.027	0.027
	d	0.0174	0.0436	0.0875	0.1764	0.4519	0.9450	2.1044	3.6750	34.3792	34.9407	35.4180	35.8367	36.2096	36.5473	36.8582	37.4126
540.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	361.209	361.043	360.767	360.207	358.487	355.462	348.620	340.002	250.153	249.202	248.481	247.903	247.435	247.053	246.723	246.220
	s	0.54732	0.52746	0.51233	0.49700	0.47602	0.45888	0.43884	0.42336	0.33012	0.32861	0.32733	0.32621	0.32520	0.32429	0.32343	0.32188
	v	58.095	23.185	11.550	5.731	2.239	1.072	0.484	0.281	0.030	0.029	0.029	0.028	0.028	0.028	0.028	0.027
	d	0.0172	0.0431	0.0866	0.1745	0.4467	0.9324	2.0653	3.5642	33.4410	34.1125	34.6654	35.1401	35.5576	35.9300	36.2730	36.8760
550.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	365.983	365.820	365.551	365.004	363.325	360.380	353.763	345.585	333.504	256.241	255.286	254.554	253.969	253.494	253.088	252.475
	s	0.55208	0.53222	0.51709	0.50177	0.48083	0.46378	0.44396	0.42892	0.41277	0.33561	0.33410	0.33283	0.33171	0.33070	0.32976	0.32811
	v	58.679	23.420	11.668	5.791	2.264	1.087	0.493	0.289	0.175	0.030	0.030	0.029	0.029	0.028	0.028	0.028
	d	0.0170	0.0427	0.0857	0.1727	0.4417	0.9204	2.0284	3.4651	5.7248	33.1969	33.8524	34.3972	34.8688	35.2848	35.6636	36.3205
560.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	370.793	370.634	370.369	369.836	368.198	365.327	358.925	351.136	340.279	263.617	262.327	261.375	260.642	260.044	259.557	258.803
	s	0.55682	0.53696	0.52184	0.50653	0.48563	0.46865	0.44904	0.43439	0.41945	0.34288	0.34104	0.33955	0.33828	0.33715	0.33614	0.33434
	v	59.263	23.655	11.786	5.852	2.290	1.100	0.502	0.296	0.184	0.031	0.030	0.030	0.029	0.029	0.029	0.028
	d	0.0169	0.0423	0.0848	0.1709	0.4367	0.9087	1.9932	3.3749	5.4211	32.1627	32.9577	33.5977	34.1351	34.6057	35.0229	35.7454
570.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	375.638	375.484	375.225	374.702	373.102	370.306	364.102	356.664	346.726	271.563	269.674	268.420	267.471	266.728	266.133	265.220
	s	0.56155	0.54170	0.52658	0.51128	0.49042	0.47351	0.45409	0.43979	0.42574	0.35064	0.34821	0.34643	0.34495	0.34368	0.34256	0.34061
	v	59.847	23.890	11.905	5.912	2.315	1.114	0.510	0.304	0.193	0.032	0.031	0.031	0.030	0.030	0.029	0.028
	d	0.0167	0.0419	0.0840	0.1692	0.4320	0.8973	1.9600	3.2924	5.1786	30.9318	31.9593	32.7232	33.3513	33.8857	34.3505	35.1459
580.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	380.519	380.368	380.115	379.604	378.040	375.314	369.300	362.177	352.974	280.692	277.506	275.736	274.511	273.572	272.835	271.722
	s	0.56626	0.54642	0.53131	0.51602	0.49519	0.47835	0.45912	0.44511	0.43178	0.35946	0.35578	0.35350	0.35175	0.35029	0.34903	0.34689
	v	60.431	24.125	12.023	5.972	2.340	1.128	0.519	0.311	0.201	0.034	0.032	0.031	0.031	0.030	0.030	0.029
	d	0.0165	0.0415	0.0832	0.1675	0.4273	0.8863	1.9280	3.2162	4.9756	29.2980	30.8003	31.7586	32.4983	33.1133	33.6399	34.5235
590.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	385.434	385.287	385.038	384.539	383.011	380.352	374.515	367.683	359.084	345.816	286.150	283.462	281.795	280.599	279.675	278.324
	s	0.57097	0.55112	0.53602	0.52074	0.49995	0.48317	0.46411	0.45038	0.43763	0.42202	0.36406	0.36089	0.35872	0.35702	0.35558	0.35321
	v	61.014	24.360	12.141	6.032	2.366	1.142	0.527	0.318	0.208	0.132	0.034	0.033	0.032	0.031	0.030	0.030
	d	0.0164	0.0411	0.0824	0.1658	0.4227	0.8757	1.8977	3.1454	4.8011	7.5523	29.3813	30.6624	31.5665	32.2844	32.8872	33.8723

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
600.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	390.384	390.238	389.996	389.508	388.014	385.420	379.751	373.184	365.100	353.603	296.985	291.833	289.436	287.843	286.689	285.039
	s	0.57566	0.55582	0.54072	0.52546	0.50470	0.48798	0.46908	0.45560	0.44334	0.42940	0.37433	0.36883	0.36597	0.36389	0.36223	0.35958
	v	61.599	24.593	12.259	6.092	2.391	1.156	0.535	0.325	0.215	0.142	0.037	0.034	0.033	0.032	0.031	0.030
	d	0.0162	0.0407	0.0816	0.1641	0.4183	0.8653	1.8687	3.0795	4.6475	7.0353	27.2737	29.3639	30.5235	31.3880	32.0812	33.1896
610.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	395.368	395.226	394.988	394.510	393.050	390.518	385.009	378.686	371.048	360.761	338.446	301.436	297.576	295.403	293.902	291.879
	s	0.58034	0.56050	0.54541	0.53015	0.50943	0.49277	0.47401	0.46077	0.44892	0.43613	0.41323	0.37785	0.37361	0.37099	0.36901	0.36600
	v	62.183	24.829	12.377	6.152	2.416	1.169	0.543	0.331	0.222	0.150	0.082	0.036	0.034	0.033	0.032	0.031
	d	0.0161	0.0403	0.0808	0.1626	0.4139	0.8553	1.8408	3.0178	4.5103	6.6522	12.1235	27.6935	29.3280	30.3942	31.2152	32.4708
620.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	400.385	400.246	400.014	399.546	398.118	395.645	390.288	384.189	376.940	367.566	352.102	314.394	306.521	303.353	301.369	298.856
	s	0.58501	0.56518	0.55009	0.53484	0.51414	0.49754	0.47893	0.46589	0.45441	0.44246	0.42594	0.38990	0.38194	0.37838	0.37595	0.37249
	v	62.764	25.063	12.495	6.212	2.441	1.183	0.551	0.338	0.228	0.158	0.101	0.040	0.036	0.034	0.033	0.032
	d	0.0159	0.0399	0.0800	0.1610	0.4097	0.8455	1.8141	2.9600	4.3870	6.3457	9.9268	24.8719	27.8929	29.2855	30.2744	31.7135
630.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	405.436	405.301	405.073	404.616	403.218	400.802	395.590	389.701	382.797	374.144	361.459	333.728	316.888	311.862	309.156	305.995
	s	0.58967	0.56984	0.55475	0.53951	0.51884	0.50229	0.48381	0.47097	0.45981	0.44852	0.43457	0.40772	0.39149	0.38623	0.38313	0.37908
	v	63.347	25.298	12.614	6.272	2.466	1.196	0.559	0.344	0.234	0.164	0.111	0.054	0.038	0.036	0.034	0.032
	d	0.0158	0.0395	0.0793	0.1594	0.4055	0.8359	1.7884	2.9053	4.2746	6.0898	8.9839	18.4851	26.0070	28.0144	29.2419	30.9114
640.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	410.522	410.388	410.165	409.718	408.349	405.988	400.912	395.221	388.628	380.569	369.570	350.082	329.339	321.163	317.347	313.314
	s	0.59431	0.57448	0.55940	0.54417	0.52353	0.50703	0.48868	0.47601	0.46513	0.45439	0.44198	0.42267	0.40286	0.39472	0.39062	0.38576
	v	63.932	25.532	12.732	6.332	2.491	1.210	0.567	0.350	0.240	0.170	0.120	0.072	0.043	0.038	0.036	0.033
	d	0.0156	0.0392	0.0785	0.1579	0.4015	0.8267	1.7637	2.8535	4.1713	5.8694	8.3629	13.8694	23.2137	26.5052	28.0966	30.0606
650.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	415.639	415.508	415.291	414.852	413.512	411.205	406.260	400.750	394.439	386.878	377.061	362.053	342.611	331.412	326.035	320.839
	s	0.59895	0.57912	0.56404	0.54882	0.52821	0.51175	0.49352	0.48102	0.47039	0.46011	0.44876	0.43351	0.41488	0.40400	0.39848	0.39257
	v	64.515	25.766	12.850	6.392	2.516	1.223	0.575	0.357	0.245	0.176	0.127	0.085	0.051	0.041	0.037	0.034
	d	0.0155	0.0388	0.0778	0.1565	0.3975	0.8177	1.7399	2.8047	4.0759	5.6768	7.8968	11.7996	19.5934	24.6481	26.8102	29.1566
660.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	420.790	420.662	420.448	420.019	418.706	416.450	411.631	406.292	400.235	393.106	384.180	371.739	354.995	342.308	335.258	328.594
	s	0.60357	0.58374	0.56867	0.55346	0.53286	0.51646	0.49834	0.48599	0.47559	0.46569	0.45515	0.44220	0.42599	0.41378	0.40675	0.39953
	v	65.100	26.	12.968	6.451	2.541	1.236	0.582	0.363	0.251	0.182	0.133	0.094	0.061	0.045	0.039	0.035
	d	0.0154	0.0385	0.0771	0.1550	0.3936	0.8089	1.7169	2.7581	3.9875	5.5051	7.5229	10.6431	16.4210	22.3824	25.3513	28.1956
670.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	425.973	425.847	425.638	425.217	423.932	421.726	417.026	411.848	406.025	399.270	391.052	380.278	366.034	353.186	344.889	336.594
	s	0.60817	0.58835	0.57328	0.55808	0.53751	0.52115	0.50313	0.49093	0.48074	0.47117	0.46126	0.44979	0.43581	0.42345	0.41532	0.40664
	v	65.681	26.235	13.085	6.511	2.565	1.250	0.590	0.368	0.256	0.187	0.139	0.101	0.070	0.050	0.042	0.037
	d	0.0152	0.0381	0.0764	0.1536	0.3898	0.8003	1.6947	2.7137	3.9050	5.3507	7.2105	9.8635	14.2439	19.9186	23.7000	27.1748
680.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	431.187	431.065	430.859	430.446	429.188	427.030	422.443	417.418	411.809	405.388	397.747	388.156	375.894	363.626	354.648	344.823
	s	0.61277	0.59295	0.57788	0.56269	0.54214	0.52582	0.50791	0.49584	0.48584	0.47657	0.46716	0.45673	0.44450	0.43265	0.42392	0.41390
	v	66.264	26.469	13.203	6.570	2.590	1.263	0.598	0.374	0.261	0.192	0.144	0.108	0.078	0.057	0.046	0.038
	d	0.0151	0.0378	0.0757	0.1522	0.3861	0.7919	1.6734	2.6715	3.8278	5.2102	6.9427	9.2807	12.7869	17.6568	21.8911	26.0971

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5. Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
690.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	436.434	436.315	436.112	435.707	434.474	432.362	427.886	423.005	417.595	411.468	404.316	395.621	384.871	373.501	364.287	353.241
	s	0.61735	0.59754	0.58247	0.56728	0.54676	0.53048	0.51266	0.50072	0.49089	0.48188	0.47290	0.46326	0.45234	0.44128	0.43234	0.42125
	v	66.848	26.704	13.321	6.630	2.615	1.276	0.605	0.380	0.266	0.197	0.149	0.113	0.085	0.063	0.050	0.040
	d	0.0150	0.0374	0.0751	0.1508	0.3824	0.7837	1.6526	2.6309	3.7549	5.0819	6.7081	8.8156	11.7567	15.8182	20.0442	24.9625
700.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	441.714	441.595	441.397	440.999	439.791	437.723	433.353	428.606	423.382	417.519	410.784	402.802	393.209	382.786	373.680	361.768
	s	0.62193	0.60211	0.58705	0.57187	0.55137	0.53513	0.51740	0.50557	0.49590	0.48712	0.47850	0.46947	0.45956	0.44932	0.44047	0.42863
	v	67.435	26.937	13.439	6.690	2.640	1.289	0.613	0.386	0.271	0.201	0.154	0.119	0.091	0.069	0.055	0.042
	d	0.0148	0.0371	0.0744	0.1495	0.3788	0.7758	1.6325	2.5922	3.6864	4.9637	6.5006	8.4297	10.9838	14.4041	18.3107	23.7778
710.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	447.023	446.908	446.712	446.322	445.139	443.114	438.845	434.228	429.173	423.554	417.179	409.782	401.094	391.562	382.755	370.322
	s	0.62648	0.60667	0.59161	0.57644	0.55596	0.53975	0.52211	0.51040	0.50088	0.49230	0.48399	0.47547	0.46633	0.45685	0.44827	0.43598
	v	68.016	27.173	13.556	6.749	2.664	1.302	0.620	0.391	0.276	0.206	0.158	0.123	0.096	0.075	0.060	0.044
	d	0.0147	0.0368	0.0738	0.1482	0.3753	0.7680	1.6131	2.5550	3.6216	4.8538	6.3139	8.1001	10.3735	13.3118	16.8001	22.5534
720.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	452.363	452.249	452.060	451.677	450.516	448.532	444.361	439.865	434.974	429.574	423.516	416.603	408.648	399.903	391.504	378.835
	s	0.63103	0.61122	0.59617	0.58100	0.56054	0.54437	0.52681	0.51520	0.50582	0.49742	0.48939	0.48127	0.47276	0.46396	0.45571	0.44323
	v	68.598	27.405	13.675	6.809	2.689	1.315	0.627	0.397	0.281	0.210	0.163	0.128	0.101	0.080	0.064	0.047
	d	0.0146	0.0365	0.0731	0.1469	0.3719	0.7604	1.5941	2.5193	3.5599	4.7514	6.1445	7.8144	9.8734	12.4521	15.5356	21.3131
730.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	457.734	457.624	457.437	457.062	455.924	453.979	449.901	445.523	440.780	435.584	429.812	423.314	415.951	407.896	399.941	387.261
	s	0.63556	0.61575	0.60071	0.58554	0.56510	0.54897	0.53148	0.51997	0.51072	0.50250	0.49470	0.48694	0.47893	0.47070	0.46284	0.45034
	v	69.181	27.640	13.792	6.868	2.714	1.328	0.635	0.402	0.286	0.215	0.167	0.132	0.106	0.085	0.069	0.050
	d	0.0145	0.0362	0.0725	0.1456	0.3685	0.7529	1.5758	2.4849	3.5016	4.6557	5.9893	7.5609	9.4530	11.7557	14.4927	20.0937
740.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	463.136	463.026	462.844	462.476	461.359	459.455	455.467	451.201	446.597	441.587	436.071	429.930	423.073	415.603	408.101	395.570
	s	0.64009	0.62028	0.60523	0.59007	0.56965	0.55355	0.53614	0.52473	0.51559	0.50752	0.49994	0.49248	0.48489	0.47715	0.46967	0.45729
	v	69.765	27.873	13.910	6.928	2.738	1.341	0.642	0.408	0.290	0.219	0.171	0.136	0.110	0.089	0.073	0.053
	d	0.0143	0.0359	0.0719	0.1443	0.3652	0.7456	1.5580	2.4516	3.4459	4.5660	5.8467	7.3348	9.0899	11.1789	13.6290	18.9330
750.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	468.569	468.461	468.281	467.920	466.824	464.957	461.056	456.896	452.427	447.589	442.303	436.478	430.047	423.087	416.013	403.746
	s	0.64460	0.62479	0.60975	0.59459	0.57419	0.55812	0.54078	0.52945	0.52043	0.51250	0.50512	0.49791	0.49068	0.48337	0.47624	0.46408
	v	70.350	28.108	14.028	6.987	2.763	1.354	0.649	0.413	0.295	0.223	0.175	0.140	0.114	0.094	0.077	0.056
	d	0.0142	0.0356	0.0713	0.1431	0.3620	0.7385	1.5407	2.4197	3.3926	4.4813	5.7147	7.1300	8.7722	10.6891	12.9073	17.8609
760.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	474.031	473.924	473.748	473.393	472.318	470.487	466.670	462.611	458.268	453.592	448.515	442.967	436.906	430.388	423.715	411.786
	s	0.64909	0.62929	0.61425	0.59910	0.57871	0.56267	0.54540	0.53416	0.52523	0.51745	0.51023	0.50326	0.49633	0.48938	0.48258	0.47070
	v	70.935	28.342	14.145	7.046	2.787	1.367	0.656	0.419	0.299	0.227	0.179	0.144	0.118	0.097	0.081	0.059
	d	0.0141	0.0353	0.0707	0.1419	0.3588	0.7316	1.5239	2.3889	3.3418	4.4013	5.5920	6.9438	8.4903	10.2666	12.2949	16.8906
770.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	479.520	479.418	479.244	478.896	477.841	476.045	472.307	468.345	464.122	459.597	454.710	449.416	443.677	437.544	431.243	419.687
	s	0.65358	0.63377	0.61873	0.60359	0.58322	0.56721	0.55001	0.53884	0.53001	0.52235	0.51529	0.50852	0.50185	0.49522	0.48872	0.47715
	v	71.513	28.576	14.262	7.106	2.812	1.380	0.663	0.424	0.304	0.231	0.183	0.148	0.121	0.101	0.085	0.062
	d	0.0140	0.0350	0.0701	0.1407	0.3557	0.7247	1.5076	2.3593	3.2931	4.3254	5.4776	6.7725	8.2370	9.8961	11.7667	16.0262

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-5, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Pressure

Temp.																
780.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	485.042	484.939	484.769	484.427	483.392	481.632	477.971	474.101	469.993	465.607	460.900	455.829	450.375	444.577	438.613	427.459
	s	0.65805	0.63824	0.62321	0.60807	0.58772	0.57173	0.55460	0.54350	0.53477	0.52722	0.52030	0.51372	0.50728	0.50092	0.49469	0.48345
	v	72.100	28.809	14.380	7.165	2.836	1.393	0.670	0.429	0.308	0.235	0.186	0.151	0.125	0.105	0.088	0.066
	d	0.0139	0.0347	0.0695	0.1396	0.3526	0.7180	1.4916	2.3305	3.2462	4.2534	5.3695	6.6142	8.0074	9.5681	11.3074	15.2599
790.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	490.590	490.490	490.323	489.987	488.970	487.245	483.658	479.877	475.876	471.622	467.078	462.213	457.012	451.515	445.856	435.106
	s	0.66251	0.64270	0.62767	0.61254	0.59220	0.57624	0.55916	0.54814	0.53950	0.53205	0.52527	0.51884	0.51261	0.50649	0.50051	0.48959
	v	72.680	29.043	14.497	7.224	2.860	1.405	0.677	0.434	0.312	0.239	0.190	0.155	0.128	0.108	0.092	0.069
	d	0.0138	0.0344	0.0690	0.1384	0.3496	0.7115	1.4761	2.3026	3.2013	4.1850	5.2684	6.4676	7.7984	9.2736	10.9023	14.5830
800.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	496.168	496.070	495.907	495.576	494.577	492.883	489.370	485.678	481.777	477.646	473.254	468.576	463.606	458.375	452.992	442.643
	s	0.66695	0.64715	0.63212	0.61699	0.59667	0.58073	0.56372	0.55277	0.54420	0.53685	0.53019	0.52392	0.51787	0.51196	0.50620	0.49560
	v	73.263	29.276	14.615	7.283	2.885	1.418	0.684	0.439	0.317	0.243	0.193	0.158	0.131	0.111	0.095	0.072
	d	0.0136	0.0342	0.0684	0.1373	0.3467	0.7051	1.4610	2.2754	3.1580	4.1197	5.1728	6.3308	7.6055	9.0070	10.5409	13.9825
810.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	501.776	501.678	501.517	501.193	500.212	498.549	495.108	491.495	487.694	483.677	479.428	474.924	470.163	465.168	460.036	450.084
	s	0.67138	0.65159	0.63656	0.62143	0.60112	0.58522	0.56825	0.55737	0.54888	0.54162	0.53507	0.52894	0.52305	0.51733	0.51177	0.50148
	v	73.848	29.511	14.732	7.343	2.909	1.431	0.691	0.445	0.321	0.246	0.197	0.161	0.135	0.114	0.098	0.074
	d	0.0135	0.0339	0.0679	0.1362	0.3438	0.6988	1.4462	2.2493	3.1163	4.0574	5.0824	6.2025	7.4271	8.7642	10.2162	13.4461
820.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	507.411	507.316	507.156	506.837	505.875	504.242	500.868	497.334	493.625	489.722	485.605	481.261	476.684	471.910	467.009	457.426
	s	0.67581	0.65601	0.64098	0.62586	0.60556	0.58968	0.57277	0.56195	0.55353	0.54636	0.53992	0.53391	0.52817	0.52262	0.51724	0.50724
	v	74.431	29.746	14.850	7.402	2.933	1.444	0.698	0.450	0.325	0.250	0.200	0.164	0.138	0.117	0.101	0.077
	d	0.0134	0.0336	0.0673	0.1351	0.3409	0.6927	1.4318	2.2239	3.0763	3.9975	4.9963	6.0819	7.2622	8.5409	9.9206	12.9682
830.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	513.073	512.979	512.823	512.510	511.563	509.961	506.652	503.196	499.576	495.776	491.783	487.586	483.183	478.606	473.915	464.689
	s	0.68021	0.66042	0.64539	0.63028	0.60999	0.59413	0.57728	0.56651	0.55816	0.55107	0.54472	0.53883	0.53323	0.52783	0.52262	0.51290
	v	75.015	29.978	14.967	7.461	2.958	1.456	0.705	0.455	0.329	0.254	0.203	0.168	0.141	0.120	0.104	0.080
	d	0.0133	0.0334	0.0668	0.1340	0.3381	0.6866	1.4177	2.1991	3.0375	3.9402	4.9148	5.9686	7.1080	8.3352	9.6513	12.5373
840.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	518.763	518.672	518.518	518.210	517.279	515.706	512.459	509.077	505.541	501.842	497.965	493.905	489.665	485.267	480.765	471.883
	s	0.68461	0.66481	0.64979	0.63468	0.61441	0.59857	0.58176	0.57105	0.56277	0.55576	0.54950	0.54371	0.53823	0.53298	0.52791	0.51845
	v	75.598	30.213	15.085	7.520	2.982	1.469	0.712	0.460	0.333	0.257	0.207	0.171	0.144	0.123	0.106	0.082
	d	0.0132	0.0331	0.0663	0.1330	0.3353	0.6807	1.4041	2.1751	3.0001	3.8852	4.8371	5.8616	6.9633	8.1442	9.4043	12.1460
850.	P	2.	5.	10.	20.	50.	100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.	1200.
	h	524.480	524.391	524.239	523.937	523.024	521.476	518.292	514.981	511.527	507.922	504.157	500.223	496.130	491.897	487.571	479.010
	s	0.68899	0.66920	0.65418	0.63907	0.61881	0.60299	0.58623	0.57558	0.56736	0.56042	0.55425	0.54855	0.54319	0.53806	0.53312	0.52392
	v	76.179	30.447	15.202	7.580	3.006	1.482	0.719	0.465	0.337	0.261	0.210	0.174	0.146	0.126	0.109	0.085
	d	0.0131	0.0328	0.0658	0.1319	0.3326	0.6749	1.3906	2.1517	2.9638	3.8322	4.7625	5.7599	6.8275	7.9665	9.1759	11.7905

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.										
60.	P	13.520	4805.252							
	h	-0.006	11.284							
	s	0.	-0.01							
	v	0.018	0.018							
	d	54.5056	55.8346							
70.	P	3586.997								
	h	12.370								
	s	0.								
	v	0.018								
	d	55.2407								
80.	P	2424.738								
	h	13.696								
	s	0.01								
	v	0.018								
	d	54.6200								
90.	P	1316.061								
	h	15.260								
	s	0.02								
	v	0.019								
	d	53.9686								
100.	P	269.227	4889.209							
	h	17.088	27.760							
	s	0.03	0.02							
	v	0.019	0.018							
	d	53.2844	54.7436							
110.	P	3621.832								
	h	28.980								
	s	0.03								
	v	0.018								
	d	54.0921								
120.	P	2418.244								
	h	30.461								
	s	0.04								
	v	0.019								
	d	53.4084								
130.	P	0.961		1279.771						
	h	200.315	Phase	32.218						
	s	0.36		0.05						
	v	71.100	Change	0.019						
	d	0.0141		52.6875						
140.	P	1.214		217.629	4604.339					
	h	203.297	Phase	34.287	44.147					
	s	0.36		0.06	0.05					
	v	57.186	Change	0.019	0.019					
	d	0.0175		51.9275	53.5347					
150.	P	0.969	1.533		3306.037					
	h	206.421	206.319	Phase	45.542					
	s	0.37	0.36		0.06					
	v	72.930	45.998	Change	0.019					
	d	0.0137	0.0217		52.8129					
160.	P	1.225	1.935		2087.198					
	h	209.503	209.380	Phase	47.251					
	s	0.37	0.36		0.07					
	v	58.625	36.999	Change	0.019					
	d	0.0171	0.0270		52.0525					
170.	P	0.977	1.546	2.440		950.051				
	h	212.722	212.627	212.478	Phase	49.294				
	s	0.38	0.37	0.36		0.08				
	v	74.763	47.136	29.769	Change	0.020				
	d	0.0134	0.0212	0.0336		51.2472				
180.	P	1.234	1.951	3.075		3981.203				
	h	215.905	215.789	215.608	Phase	60.486				
	s	0.38	0.37	0.36		0.08				
	v	60.084	37.901	23.958	Change	0.019				
	d	0.0166	0.0264	0.0417		52.1748				
190.	P	0.984	1.558	2.461	3.871		2687.320			
	h	219.216	219.127	218.988	218.768	Phase	62.162			
	s	0.39	0.38	0.37	0.36		0.09			
	v	76.616	48.292	30.486	19.290	Change	0.019			
	d	0.0131	0.0207	0.0328	0.0518		51.3683			
200.	P	1.243	1.966	3.101	4.867		1488.574			
	h	222.496	222.389	222.220	221.954	Phase	64.215			
	s	0.39	0.38	0.37	0.36		0.10			
	v	61.559	38.824	24.528	15.540	Change	0.020			
	d	0.0162	0.0258	0.0408	0.0643		50.5128			
210.	P	0.990	1.568	2.479	3.903	6.111		401.247	4440.995	
	h	225.900	225.818	225.687	225.482	225.161	Phase	66.700	75.275	
	s	0.40	0.39	0.38	0.37	0.36		0.11	0.10	
	v	78.506	49.473	31.221	19.744	12.527	Change	0.020	0.019	
	d	0.0127	0.0202	0.0320	0.0506	0.0798		49.6062	51.4834	
220.	P	1.250	1.978	3.123	4.908	7.661		3089.488		
	h	229.277	229.178	229.018	228.769	228.381	Phase	76.965		
	s	0.40	0.39	0.38	0.37	0.36		0.11		
	v	63.079	39.770	25.113	15.900	10.105	Change	0.020		
	d	0.0159	0.0251	0.0398	0.0629	0.0990		50.6263		
230.	P	0.995	1.577	2.494	3.931	6.163	9.585		1852.259	
	h	232.772	232.695	232.573	232.381	232.079	231.611	Phase	79.091	
	s	0.41	0.40	0.39	0.38	0.37	0.36		0.12	
	v	80.461	50.692	31.978	20.212	12.812	8.161	Change	0.020	
	d	0.0124	0.0197	0.0313	0.0495	0.0780	0.1225		49.7184	

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.											
240.	P	1.256	1.989	3.141	4.942	7.727	11.966		732.643	4698.650	
	h	236.244	236.151	236.002	235.768	235.403	234.838	Phase	81.683	89.929	
	s	0.41	0.40	0.39	0.38	0.37	0.36		0.13	0.12	
	v	64.645	40.748	25.721	16.273	10.333	6.598	Change	0.021	0.020	
	d	0.0155	0.0245	0.0389	0.0615	0.0968	0.1516		48.7501	50.7321	
250.	P	0.999	1.584	2.506	3.953	6.206	9.671	14.901		3310.207	
	h	239.828	239.756	239.642	239.462	239.178	238.737	238.057	Phase	91.693	
	s	0.42	0.41	0.40	0.39	0.38	0.37	0.36		0.13	
	v	82.484	51.955	32.765	20.699	13.113	8.341	5.341	Change	0.020	
	d	0.0121	0.0192	0.0305	0.0483	0.0763	0.1199	0.1872		49.8205	
260.	P	1.260	1.996	3.155	4.969	7.781	12.078	18.501		2045.876	
	h	243.394	243.307	243.167	242.948	242.605	242.072	241.257	Phase	93.936	
	s	0.42	0.41	0.40	0.39	0.38	0.37	0.36		0.14	
	v	66.279	41.768	26.356	16.665	10.573	6.741	4.331	Change	0.020	
	d	0.0151	0.0239	0.0379	0.0600	0.0946	0.1483	0.2309		48.8503	
270.	P	1.002	1.589	2.515	3.970	6.239	9.740	15.047	22.891		916.134	4766.197
	h	247.068	247.	246.892	246.723	246.457	246.042	245.400	244.425	Phase	96.708	104.480
	s	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36		0.15	0.14
	v	84.598	53.277	33.587	21.210	13.427	8.533	5.455	3.518	Change	0.021	0.020
	d	0.0118	0.0188	0.0298	0.0471	0.0745	0.1172	0.1833	0.2842		47.8139	49.9111
280.	P	1.263	2.002	3.165	4.989	7.822	12.167	18.694		3359.080		
	h	250.725	250.643	250.512	250.307	249.983	249.482	248.711	Phase	106.378		
	s	0.43	0.42	0.41	0.40	0.39	0.38	0.37		0.15		
	v	67.992	42.838	27.022	17.080	10.826	6.895	4.422	Change	0.020		
	d	0.0147	0.0233	0.0370	0.0585	0.0924	0.1450	0.2262		48.9377		
290.	P	1.003	1.591	2.520	3.980	6.262	9.791	15.164	23.151		2092.336	
	h	254.485	254.422	254.321	254.163	253.912	253.521	252.915	251.992	Phase	108.814	
	s	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37		0.16	
	v	86.812	54.668	34.455	21.750	13.760	8.737	5.578	3.590	Change	0.021	
	d	0.0115	0.0183	0.0290	0.0460	0.0727	0.1145	0.1793	0.2785		47.9001	
300.	P	1.264	2.004	3.170	5.001	7.850	12.233	18.849	28.561		979.207	4665.808
	h	258.234	258.156	258.034	257.840	257.537	257.063	256.335	255.231	Phase	111.850	118.984
	s	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37		0.17	0.16
	v	69.792	43.966	27.725	17.515	11.095	7.058	4.519	2.921	Change	0.021	0.020
	d	0.0143	0.0227	0.0361	0.0571	0.0901	0.1417	0.2213	0.3423		46.7909	49.0131
310.	P	1.003	1.591	2.521	3.985	6.275	9.825	15.249	23.359	35.089		3262.866
	h	262.080	262.021	261.927	261.777	261.542	261.174	260.602	259.728	258.413	Phase	121.091
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37		0.17
	v	89.152	56.135	35.373	22.321	14.115	8.954	5.709	3.668	2.382	Change	0.021
	d	0.0112	0.0178	0.0283	0.0448	0.0708	0.1117	0.1751	0.2726	0.4198		47.9711
320.	P	1.263	2.003	3.170	5.004	7.864	12.275	18.963	28.842	42.897		2016.595
	h	265.918	265.845	265.730	265.548	265.262	264.816	264.128	263.080	261.523	Phase	123.803
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37		0.18
	v	71.698	45.160	28.472	17.979	11.382	7.234	4.625	2.983	1.948	Change	0.021
	d	0.0139	0.0221	0.0351	0.0556	0.0879	0.1382	0.2162	0.3353	0.5134		46.8572

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.														
330.	P	1.001	1.589	2.518	3.982	6.277	9.840	15.304	23.510	35.473	52.156		942.553	4421.604
	h	269.849	269.794	269.705	269.564	269.343	268.996	268.457	267.629	266.381	264.543	Phase	127.192	133.512
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37		0.19	0.18
	v	91.637	57.687	36.344	22.927	14.490	9.187	5.851	3.752	2.431	1.598	Change	0.022	0.021
	d	0.0109	0.0173	0.0275	0.0436	0.0690	0.1089	0.1709	0.2665	0.4113	0.6259		45.6651	48.0285
340.	P	1.260	1.998	3.165	4.999	7.863	12.293	19.035	29.054	43.425		3048.174		
	h	273.775	273.706	273.598	273.427	273.157	272.738	272.087	271.094	269.612	Phase	135.916		
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38		0.19		
	v	73.731	46.428	29.265	18.472	11.688	7.422	4.739	3.050	1.987	Change	0.021		
	d	0.0136	0.0215	0.0342	0.0541	0.0856	0.1347	0.2110	0.3278	0.5033		46.9101		
350.	P	0.998	1.584	2.511	3.973	6.267	9.837	15.326	23.609	35.763	52.884		1852.017	
	h	277.790	277.738	277.654	277.522	277.314	276.987	276.478	275.694	274.509	272.757	Phase	139.008	
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38		0.20	
	v	94.273	59.345	37.382	23.575	14.894	9.435	6.003	3.844	2.485	1.628	Change	0.022	
	d	0.0106	0.0169	0.0268	0.0424	0.0671	0.1060	0.1666	0.2601	0.4024	0.6142		45.7139	
360.	P	1.255	1.991	3.154	4.984	7.848	12.286	19.064	29.191	43.834	64.027		838.167	4063.294
	h	281.801	281.737	281.635	281.474	281.221	280.825	280.211	279.270	277.860	275.800	Phase	142.840	148.160
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38		0.21	0.20
	v	75.885	47.782	30.110	19.001	12.017	7.624	4.862	3.124	2.030	1.339	Change	0.023	0.021
	d	0.0132	0.0209	0.0332	0.0526	0.0832	0.1312	0.2057	0.3201	0.4927	0.7470		44.4257	46.9465
370.	P	0.993	1.577	2.500	3.957	6.246	9.815	15.317	23.653	35.962	53.458	77.013		2745.547
	h	285.900	285.850	285.771	285.647	285.451	285.144	284.664	283.923	282.799	281.130	278.721	Phase	150.959
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38		0.21
	v	97.096	61.113	38.491	24.267	15.325	9.703	6.167	3.944	2.544	1.662	1.105	Change	0.022
	d	0.0103	0.0164	0.0260	0.0412	0.0653	0.1031	0.1621	0.2536	0.3930	0.6016	0.9053		45.7429
380.	P	1.248	1.980	3.138	4.961	7.818	12.255	19.053	29.260	44.121	64.836	91.942		1622.579
	h	289.995	289.935	289.839	289.687	289.449	289.075	288.496	287.607	286.267	284.299	281.506	Phase	154.526
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38		0.22
	v	78.200	49.233	31.020	19.567	12.369	7.842	4.996	3.205	2.077	1.366	0.915	Change	0.022
	d	0.0128	0.0203	0.0322	0.0511	0.0808	0.1275	0.2002	0.3120	0.4814	0.7323	1.0925		44.4529
390.	P	0.987	1.566	2.484	3.934	6.214	9.773	15.274	23.642	36.069	53.881	78.147		696.821	3623.716
	h	294.175	294.128	294.054	293.938	293.754	293.463	293.011	292.312	291.246	289.656	287.352	Phase	158.911	163.036
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39		0.23	0.22
	v	100.119	63.010	39.679	25.012	15.789	9.991	6.345	4.052	2.609	1.700	1.126	Change	0.023	0.022
	d	0.0100	0.0159	0.0252	0.0400	0.0633	0.1001	0.1576	0.2468	0.3832	0.5882	0.8883		43.0588	45.7566
400.	P	1.238	1.965	3.115	4.929	7.773	12.198	18.998	29.253	44.290	65.445	93.511		2392.251	
	h	298.354	298.296	298.207	298.065	297.840	297.489	296.941	296.100	294.828	292.952	290.272	Phase	166.342	
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39		0.23	
	v	80.687	50.787	31.994	20.178	12.748	8.078	5.141	3.293	2.129	1.396	0.932	Change	0.022	
	d	0.0124	0.0197	0.0313	0.0496	0.0784	0.1238	0.1945	0.3037	0.4696	0.7165	1.0730		44.4605	
410.	P	0.978	1.553	2.464	3.904	6.169	9.711	15.199	23.575	36.081	54.144	79.028	111.104		1365.073	4479.045
	h	302.613	302.569	302.500	302.391	302.218	301.945	301.519	300.858	299.849	298.337	296.134	293.037	Phase	170.489	175.217
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39		0.24	0.23
	v	103.365	65.047	40.957	25.811	16.289	10.302	6.538	4.170	2.680	1.742	1.150	0.774	Change	0.023	0.022
	d	0.0097	0.0154	0.0244	0.0387	0.0614	0.0971	0.1530	0.2398	0.3731	0.5740	0.8698	1.2914		43.0616	45.7536

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																
420.	P	1.227	1.947	3.088	4.887	7.712	12.116	18.902	29.179	44.338	65.860	94.803	130.933		548.496	3139.940
	h	306.875	306.821	306.737	306.603	306.392	306.060	305.545	304.749	303.544	301.756	299.186	295.630	Phase	175.539	178.272
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39		0.25	0.24
	v	83.349	52.465	33.043	20.835	13.158	8.332	5.297	3.388	2.187	1.429	0.951	0.646	Change	0.024	0.023
	d	0.0120	0.0191	0.0303	0.0480	0.0760	0.1200	0.1888	0.2951	0.4573	0.6996	1.0520	1.5476		41.5327	44.4442
430.	P	0.968	1.537	2.440	3.866	6.112	9.630	15.092	23.456	36.001	54.256	79.663	112.889		2018.014	
	h	311.213	311.172	311.106	311.004	310.840	310.585	310.183	309.560	308.606	307.170	305.067	302.092	Phase	182.197	
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40		0.25	
	v	106.857	67.242	42.332	26.673	16.827	10.638	6.746	4.298	2.758	1.789	1.177	0.789	Change	0.023	
	d	0.0094	0.0149	0.0236	0.0375	0.0594	0.0940	0.1482	0.2327	0.3625	0.5591	0.8499	1.2670		43.0356	
440.	P	1.213	1.926	3.054	4.836	7.637	12.009	18.764	29.032	44.264	66.074	95.754	133.412		1113.005	3865.873
	h	315.554	315.504	315.425	315.300	315.102	314.789	314.304	313.554	312.411	310.711	308.252	304.827	Phase	187.040	190.303
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40		0.26	0.25
	v	86.223	54.267	34.174	21.543	13.601	8.607	5.468	3.493	2.250	1.467	0.972	0.658	Change	0.024	0.023
	d	0.0116	0.0184	0.0293	0.0464	0.0735	0.1162	0.1829	0.2863	0.4444	0.6817	1.0288	1.5200		41.5054	44.4095
450.	P	0.956	1.519	2.411	3.821	6.044	9.530	14.952	23.281	35.831	54.213	80.043	114.312	156.339		427.332	2651.581
	h	319.971	319.932	319.870	319.774	319.621	319.380	319.002	318.415	317.514	316.152	314.148	311.292	307.380	Phase	192.857	194.015
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40		0.27	0.26
	v	110.630	69.603	43.815	27.604	17.410	11.001	6.972	4.438	2,844	1.840	1.207	0.806	0.551	Change	0.025	0.023
	d	0.0090	0.0144	0.0228	0.0362	0.0574	0.0909	0.1434	0.2254	0.3517	0.5435	0.8286	1.2405	1.8152		39.8066	42.9913
460.	P	1.197	1.901	3.015	4.776	7.546	11.877	18.584	28.816	44.076	66.092	96.390	135.413	181.556		1660.568	4565.952
	h	324.391	324.345	324.269	324.152	323.967	323.674	323.216	322.507	321.427	319.812	317.463	314.173	309.740	Phase	198.669	202.422
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40		0.27	0.26
	v	89.324	56.218	35.396	22.309	14.081	8.906	5.653	3.607	2.319	1.508	0.996	0.671	0.464	Change	0.024	0.023
	d	0.0112	0.0178	0.0283	0.0448	0.0710	0.1123	0.1769	0.2773	0.4311	0.6630	1.0038	1.4892	2.1572		41.4522	44.3578
470.	P	0.943	1.497	2.377	3.769	5.964	9.411	14.782	23.054	35.569	54.014	80.170	115.317	159.176	208.832		897.017
	h	328.884	328.848	328.791	328.701	328.556	328.330	327.975	327.422	326.570	325.282	323.374	320.640	316.870	311.895	Phase	204.315
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40		0.28
	v	114.691	72.163	45.423	28.610	18.040	11.395	7.216	4.589	2.937	1.896	1.240	0.825	0.562	0.392	Change	0.025
	d	0.0087	0.0139	0.0220	0.0350	0.0554	0.0878	0.1386	0.2179	0.3405	0.5273	0.8062	1.2114	1.7807	2.5506		39.7697
470.	P	3260.655														
	h	205.931														
	s	0.27														
	v	0.023														
	d	42.9254														
480.	P	1.179	1.872	2.971	4.707	7.441	11.722	18.365	28.533	43.769	65.916	96.704	136.933	185.479		355.455	2189.220
	h	333.384	333.339	333.270	333.159	332.983	332.709	332.279	331.612	330.591	329.059	326.820	323.661	319.379	Phase	210.990	210.408
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41		0.29	0.28
	v	92.686	58.323	36.720	23.138	14.598	9.230	5.854	3.731	2.395	1.554	1.023	0.687	0.472	Change	0.026	0.024
	d	0.0108	0.0171	0.0272	0.0432	0.0685	0.1083	0.1708	0.2680	0.4175	0.6434	0.9772	1.4556	2.1186		37.8671	41.3764
490.	P	0.927	1.473	2.339	3.710	5.873	9.273	14.580	22.775	35.223	53.672	80.051	115.925	161.429	214.168		1351.249
	h	337.950	337.917	337.863	337.778	337.644	337.432	337.097	336.578	335.775	334.555	332.744	330.129	326.504	321.680	Phase	215.904
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41		0.29
	v	119.097	74.929	47.159	29.700	18.723	11.823	7.483	4.755	3.038	1.958	1.278	0.847	0.574	0.399	Change	0.025
	d	0.0084	0.0133	0.0212	0.0337	0.0534	0.0846	0.1336	0.2103	0.3291	0.5107	0.7827	1.1804	1.7424	2.5089		39.6891

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.															
490.	P	3841.126													
	h	217.932													
	s	0.28													
	v	0.023													
	d	42.8368													
500.	P	1.159	1.840	2.921	4.629	7.322	11.543	18.106	28.182	43.353	65.548	96.708	137.967	188.712	244.937	
	h	342.527	342.485	342.419	342.315	342.152	341.894	341.491	340.863	339.899	338.447	336.318	333.292	329.158	323.773	
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	
	v	96.318	60.603	38.150	24.034	15.161	9.581	6.073	3.867	2.479	1.605	1.053	0.705	0.482	0.338	
	d	0.0104	0.0165	0.0262	0.0416	0.0660	0.1044	0.1647	0.2586	0.4035	0.6232	0.9493	1.4194	2.0758	2.9555	
510.	P	0.911	1.447	2.297	3.644	5.771	9.118	14.349	22.446	34.788	53.182	79.695	116.136	163.066	218.668	277.395
	h	347.168	347.136	347.087	347.005	346.880	346.681	346.368	345.880	345.124	343.972	342.252	339.761	336.280	331.613	325.652
	s	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41
	v	123.871	77.926	49.041	30.880	19.462	12.285	7.772	4.934	3.150	2.026	1.319	0.872	0.588	0.406	0.289
	d	0.0081	0.0128	0.0204	0.0324	0.0514	0.0814	0.1287	0.2027	0.3175	0.4935	0.7584	1.1473	1.7005	2.4609	3.4636
520.	P	1.136	1.805	2.866	4.543	7.189	11.342	17.810	27.768	42.827	64.994	96.401	138.562	191.206	251.081	311.051
	h	351.819	351.779	351.718	351.621	351.468	351.227	350.848	350.257	349.349	347.977	345.952	343.058	339.082	333.858	327.313
	s	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41
	v	100.297	63.078	39.702	25.010	15.772	9.963	6.311	4.014	2.570	1.660	1.087	0.724	0.493	0.344	0.246
	d	0.0100	0.0159	0.0252	0.0400	0.0634	0.1004	0.1584	0.2491	0.3892	0.6023	0.9202	1.3813	2.0282	2.9030	4.0381
520.	P		1117.243	3175.812												
	h	Phase	234.042	234.183												
	s		0.31	0.30												
	v	Change	0.027	0.024												
	d		37.7286	41.1537												
530.	P	0.892	1.418	2.251	3.572	5.659	8.946	14.090	22.069	34.275	52.555	79.094	115.956	164.115	222.305	285.572
	h	356.533	356.503	356.457	356.383	356.264	356.077	355.784	355.325	354.614	353.528	351.901	349.528	346.192	341.688	335.893
	s	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	129.080	81.175	51.085	32.165	20.267	12.788	8.087	5.130	3.271	2.101	1.364	0.899	0.604	0.415	0.294
	d	0.0077	0.0123	0.0196	0.0311	0.0493	0.0782	0.1237	0.1949	0.3057	0.4760	0.7331	1.1126	1.6558	2.4074	3.4064
530.	P		664.766	2205.508	4918.868											
	h	Phase	241.545	239.423	242.156											
	s		0.32	0.31	0.30											
	v	Change	0.028	0.025	0.023											
	d		35.6953	39.4446	42.6066											
540.	P	1.112	1.767	2.805	4.449	7.043	11.119	17.479	27.294	42.195	64.262	95.793	138.623	192.970	256.216	321.715
	h	361.258	361.221	361.164	361.073	360.930	360.704	360.349	359.795	358.940	357.645	355.724	352.963	349.143	344.087	337.709
	s	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	104.558	65.763	41.391	26.069	16.435	10.378	6.570	4.176	2.669	1.721	1.124	0.746	0.506	0.352	0.251
	d	0.0096	0.0152	0.0242	0.0384	0.0608	0.0964	0.1522	0.2395	0.3746	0.5809	0.8899	1.3405	1.9767	2.8435	3.9769
540.	P		407.051	1477.642	3627.526											
	h	Phase	250.068	245.760	246.194											
	s	0.33	0.32	0.31												
	v	Change	0.030	0.027	0.024											
	d		33.4967	37.5882	41.0065											

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																
550.	P	1.386	2.201	3.493	5.537	8.756	13.803	21.648	33.682	51.793	78.268	115.397	164.548	225.069	292.601	358.958
	h	366.016	365.972	365.903	365.792	365.618	365.343	364.914	364.246	363.223	361.685	359.431	356.241	351.902	346.272	339.318
	s	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	84.711	53.303	33.558	21.142	13.337	8.429	5.344	3.404	2.183	1.414	0.929	0.622	0.426	0.299	0.217
	d	0.0118	0.0188	0.0298	0.0473	0.0750	0.1186	0.1871	0.2938	0.4582	0.7072	1.0765	1.6080	2.3488	3.3414	4.6181
550.	P		973.806	2599.385												
	h	Phase	253.189	251.335												
	s		0.33	0.32												
	v	Change	0.028	0.025												
	d		35.5674	39.2818												
560.	P	1.086	1.726	2.741	4.347	6.885	10.876	17.113	26.763	41.468	63.360	94.890	138.205	194.005	260.305	331.085	396.727
	h	370.840	370.808	370.754	370.669	370.534	370.323	369.991	369.471	368.668	367.448	365.630	363.	359.340	354.455	348.246	340.733
	s	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	109.197	68.687	43.226	27.220	17.156	10.830	6.853	4.351	2.778	1.789	1.165	0.771	0.520	0.360	0.256	0.188
	d	0.0092	0.0146	0.0231	0.0367	0.0583	0.0923	0.1459	0.2298	0.3599	0.5591	0.8586	1.2978	1.9216	2.7776	3.9060	5.3326
560.	P		668.628	1818.473	4053.482											
	h	Phase	261.650	257.599	258.283											
	s		0.34	0.33	0.32											
	v	Change	0.030	0.027	0.024											
	d		33.4086	37.4099	40.8396											
570.	P	1.352	2.148	3.409	5.405	8.553	13.492	21.184	33.019	50.905	77.217	114.462	164.460	226.954	298.431	371.228	434.571
	h	375.672	375.630	375.566	375.462	375.300	375.043	374.640	374.014	373.053	371.602	369.464	366.417	362.248	356.797	350.006	341.957
	s	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
	v	88.558	55.716	35.073	22.093	13.933	8.803	5.577	3.548	2.272	1.469	0.962	0.642	0.437	0.306	0.220	0.163
	d	0.0113	0.0179	0.0285	0.0453	0.0718	0.1136	0.1793	0.2818	0.4401	0.6807	1.0391	1.5585	2.2859	3.2681	4.5427	6.1264
570.	P		522.525	1269.143	2966.992											
	h	Phase	271.055	264.968	263.335											
	s		0.35	0.34	0.33											
	v	Change	0.032	0.028	0.026											
	d		31.1972	35.3896	39.0911											
580.	P	1.059	1.682	2.672	4.239	6.715	10.614	16.716	26.178	40.643	62.293	93.705	137.318	194.294	263.348	339.090	412.439
	h	380.567	380.534	380.485	380.406	380.281	380.083	379.771	379.285	378.534	377.384	375.667	373.168	369.668	364.957	358.926	351.565
	s	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43
	v	114.251	71.859	45.220	28.473	17.944	11.323	7.161	4.544	2.898	1.862	1.210	0.798	0.537	0.370	0.261	0.190
	d	0.0088	0.0139	0.0221	0.0351	0.0557	0.0883	0.1397	0.2201	0.3451	0.5370	0.8266	1.2534	1.8632	2.7061	3.8255	5.2546
580.	P	472.132		921.733	2140.493	4450.027										
	h	343.012	Phase	273.401	269.537	270.439										
	s	0.42		0.35	0.34	0.33										
	v	0.143	Change	0.030	0.027	0.025										
	d	7.0023		33.2333	37.2068	40.6515										
590.	P	1.316	2.091	3.320	5.265	8.335	13.157	20.679	32.285	49.896	75.964	113.174	163.722	227.932	303.022	381.854	454.210
	h	385.467	385.430	385.369	385.273	385.121	384.881	384.505	383.919	383.016	381.649	379.626	376.725	372.728	367.456	360.845	352.949
	s	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43
	v	92.730	58.348	36.722	23.129	14.582	9.210	5.831	3.707	2.371	1.529	0.999	0.664	0.451	0.314	0.225	0.165
	d	0.0108	0.0171	0.0272	0.0432	0.0686	0.1086	0.1715	0.2698	0.4218	0.6538	1.0007	1.5062	2.2185	3.1879	4.4541	6.0434

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																
590.	P	509.192		737.947	1549.317	3312.427										
	h	343.923	Phase	282.760	276.874	275.422										
	s	0.42		0.36	0.35	0.34										
	v	0.126	Change	0.032	0.028	0.026										
	d	7.9647		31.0326	35.1735	38.8801										
600.	P	1.029	1.636	2.598	4.124	6.535	10.335	16.288	25.540	39.733	61.074	92.251	135.978	193.922	265.309	345.651	426.349
	h	390.431	390.401	390.355	390.280	390.164	389.979	389.689	389.235	388.529	387.451	385.831	383.462	380.117	375.591	369.744	362.552
	s	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44
	v	119.747	75.321	47.397	29.837	18.800	11.860	7.497	4.754	3.028	1.943	1.260	0.828	0.555	0.380	0.268	0.194
	d	0.0084	0.0133	0.0211	0.0335	0.0532	0.0843	0.1334	0.2104	0.3302	0.5147	0.7940	1.2077	1.8027	2.6294	3.7360	5.1602
600.	P	496.315	546.002	570.540		670.139	1163.831	2441.619	4815.157								
	h	354.147	344.710	334.569	Phase	292.868	285.290	281.586	282.659								
	s	0.43	0.42	0.41		0.37	0.36	0.35	0.34								
	v	0.145	0.111	0.087	Change	0.035	0.030	0.027	0.025								
	d	6.9179	9.0261	11.5469		28.9080	33.0101	36.9724	40.4396								
610.	P	1.279	2.032	3.226	5.117	8.103	12.800	20.138	31.490	48.776	74.509	111.540	162.417	228.010	306.319	390.885	471.961
	h	395.402	395.366	395.309	395.221	395.078	394.855	394.504	393.956	393.110	391.824	389.916	387.157	383.334	378.249	371.821	364.079
	s	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44
	v	97.295	61.209	38.522	24.260	15.292	9.654	6.109	3.880	2.478	1.596	1.040	0.689	0.466	0.322	0.230	0.168
	d	0.0103	0.0163	0.0260	0.0412	0.0654	0.1036	0.1637	0.2577	0.4035	0.6266	0.9614	1.4521	2.1475	3.1010	4.3554	5.9441
610.	P	538.535	583.072	604.968	613.221	621.522	670.076	946.723	1812.166	3631.569							
	h	355.193	345.406	335.057	324.460	313.855	303.534	294.642	288.903	287.590							
	s	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36	0.35							
	v	0.127	0.098	0.076	0.057	0.044	0.037	0.032	0.029	0.026							
	d	7.8810	10.2101	13.2071	17.6071	22.8257	26.8934	30.8004	34.9217	38.6440							
620.	P	0.999	1.587	2.522	4.002	6.345	10.039	15.836	24.859	38.741	59.713	90.550	134.197	192.782	266.212	350.732	438.304
	h	400.432	400.404	400.362	400.292	400.185	400.013	399.741	399.318	398.658	397.647	396.123	393.880	390.695	386.352	380.696	373.694
	s	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45
	v	125.755	79.094	49.768	31.328	19.735	12.447	7.864	4.983	3.172	2.032	1.314	0.862	0.575	0.392	0.275	0.198
	d	0.0080	0.0126	0.0201	0.0319	0.0507	0.0803	0.1272	0.2007	0.3153	0.4922	0.7609	1.1608	1.7392	2.5481	3.6386	5.0505
620.	P	518.331	580.982	621.286	643.781	663.594	699.384	848.455	1394.361	2720.962							
	h	365.432	356.111	346.043	335.588	324.981	314.496	304.760	297.308	293.727							
	s	0.44	0.43	0.42	0.41002	0.40	0.39	0.38	0.37	0.36							
	v	0.147	0.112	0.087	0.066	0.050	0.040	0.035	0.031	0.027							
	d	6.8105	8.9415	11.5558	15.1228	20.0927	24.8324	28.6428	32.7517	36.7121							
630.	P	1.239	1.969	3.127	4.962	7.861	12.424	19.564	30.634	47.554	72.872	109.590	160.565	227.238	308.349	398.223	487.561
	h	405.471	405.438	405.385	405.303	405.172	404.963	404.636	404.124	403.333	402.126	400.327	397.713	394.062	389.169	382.932	375.366
	s	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45
	v	102.263	64.334	40.485	25.492	16.067	10.139	6.413	4.070	2.596	1.669	1.085	0.716	0.482	0.332	0.235	0.172
	d	0.0098	0.0155	0.0247	0.0392	0.0622	0.0986	0.1559	0.2457	0.3851	0.5991	0.9216	1.3964	2.0737	3.0083	4.2472	5.8267
630.	P	565.464	624.071	662.519	692.601	731.196	821.504	1146.254	2058.034	3923.510							
	h	366.625	356.941	346.656	336.126	325.607	315.426	306.672	301.044	299.833							
	s	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37	0.36							
	v	0.129	0.099	0.076	0.058	0.045	0.038	0.033	0.029	0.026							
	d	7.7659	10.1134	13.1088	17.3332	22.4368	26.5706	30.5265	34.6408	38.3825							

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																
640.	P	0.967	1.537	2.442	3.876	6.147	9.730	15.358	24.136	37.679	58.218	88.612	132.003	190.968	266.030	354.293	448.452
	h	410.568	410.542	410.503	410.439	410.338	410.178	409.926	409.530	408.914	407.968	406.536	404.421	401.394	397.237	391.780	384.961
	s	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46
	v	132.312	83.216	52.359	32.956	20.757	13.088	8.266	5.235	3.328	2.129	1.374	0.899	0.598	0.406	0.283	0.203
	d	0.0076	0.0120	0.0191	0.0303	0.0482	0.0764	0.1210	0.1910	0.3005	0.4696	0.7276	1.1129	1.6736	2.4626	3.5336	4.9316
640.	P	538.213	613.387	668.969	710.614	754.907	825.963	1019.323	1610.517	2978.284							
	h	376.860	367.678	357.699	347.291	336.765	326.402	316.811	309.462	305.964							
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37							
	v	0.150	0.113	0.087	0.067	0.051	0.041	0.035	0.031	0.027							
	d	6.6857	8.8173	11.4293	14.9230	19.7253	24.4389	28.3366	32.4556	36.4245							
650.	P	1.199	1.905	3.025	4.800	7.608	12.031	18.960	29.729	46.239	71.067	107.331	158.181	225.679	309.085	403.823	501.011
	h	415.674	415.644	415.594	415.517	415.395	415.202	414.896	414.420	413.682	412.553	410.859	408.387	404.906	400.215	394.176	386.794
	s	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46
	v	107.698	67.753	42.630	26.840	16.912	10.670	6.745	4.278	2.726	1.750	1.135	0.747	0.501	0.344	0.242	0.176
	d	0.0093	0.0148	0.0235	0.0373	0.0591	0.0937	0.1483	0.2338	0.3668	0.5716	0.8813	1.3395	1.9978	2.9103	4.1300	5.6952
650.	P	590.003	662.508	718.	769.351	836.306	966.378	1334.812	2285.957	4188.035							
	h	378.200	368.636	358.435	347.967	337.536	327.478	318.845	313.295	312.150							
	s	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38	0.37							
	v	0.131	0.100	0.077	0.059	0.045	0.038	0.033	0.029	0.026							
	d	7.6301	9.9742	12.9326	17.0393	22.0197	26.2217	30.2159	34.3307	38.0951							
660.	P	0.934	1.485	2.359	3.745	5.940	9.407	14.859	23.376	36.548	56.606	86.459	129.429	188.484	264.790	356.346	456.570
	h	420.835	420.812	420.775	420.715	420.622	420.474	420.239	419.872	419.297	418.414	417.071	415.077	412.209	408.242	402.985	396.367
	s	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47
	v	139.460	87.722	55.188	34.733	21.874	13.789	8.706	5.510	3.500	2.236	1.441	0.939	0.623	0.421	0.292	0.208
	d	0.0072	0.0114	0.0181	0.0288	0.0457	0.0725	0.1149	0.1815	0.2857	0.4472	0.6941	1.0646	1.6064	2.3734	3.4228	4.8012
660.	P	555.560	643.235	714.222	774.728	842.722	946.767	1181.821	1811.478	3212.982							
	h	388.442	379.399	369.518	359.190	348.739	338.476	329.003	321.745	318.293							
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38							
	v	0.153	0.115	0.089	0.068	0.052	0.042	0.036	0.031	0.028							
	d	6.5419	8.6679	11.2650	14.6856	19.3427	24.0370	28.0048	32.1242	36.1095							
670.	P	1.156	1.838	2.919	4.634	7.346	11.622	18.331	28.776	44.841	69.109	104.796	155.312	223.205	308.550	407.625	512.237
	h	426.008	425.981	425.935	425.862	425.749	425.569	425.287	424.844	424.154	423.099	421.510	419.177	415.872	411.380	405.548	398.358
	s	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47
	v	113.635	71.485	44.979	28.314	17.836	11.250	7.109	4.506	2.868	1.838	1.189	0.780	0.521	0.356	0.250	0.180
	d	0.0088	0.0140	0.0222	0.0353	0.0561	0.0889	0.1407	0.2219	0.3487	0.5441	0.8408	1.2817	1.9187	2.8079	4.0048	5.5515
670.	P	611.990	698.262	770.829	842.862	936.878	1103.860	1511.390	2495.476	4425.210							
	h	389.925	380.494	370.377	359.992	349.637	339.689	331.161	325.656	324.538							
	s	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39	0.38							
	v	0.134	0.102	0.079	0.060	0.046	0.039	0.033	0.029	0.026							
	d	7.4750	9.8068	12.7297	16.7205	21.5981	25.8532	29.8707	33.9910	37.7824							
680.	P	0.900	1.431	2.274	3.610	5.728	9.075	14.342	22.585	35.362	54.869	84.107	126.493	185.374	262.532	356.892	462.639
	h	431.233	431.211	431.177	431.122	431.036	430.898	430.680	430.338	429.805	428.980	427.725	425.851	423.141	419.360	414.312	407.902
	s	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
	v	147.307	92.652	58.285	36.680	23.096	14.556	9.187	5.811	3.689	2.354	1.514	0.984	0.650	0.438	0.302	0.215
	d	0.0068	0.0108	0.0172	0.0273	0.0433	0.0687	0.1088	0.1721	0.2711	0.4248	0.6606	1.0158	1.5378	2.2816	3.3062	4.6613

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																
680.	P	570.477	670.321	756.620	835.795	926.629	1061.528	1334.778	1998.502	3424.989						
	h	400.165	391.269	381.504	371.246	360.883	350.715	341.341	334.146	330.711						
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39						
	v	0.157	0.118	0.090	0.069	0.053	0.042	0.036	0.031	0.028						
	d	6.3838	8.4977	11.0730	14.4287	18.9487	23.6244	27.6459	31.7668	35.7672						
690.	P	1.113	1.769	2.811	4.462	7.076	11.201	17.679	27.784	43.372	67.015	102.004	151.975	219.970	306.786	409.635	521.103
	h	436.470	436.444	436.402	436.336	436.231	436.064	435.802	435.390	434.749	433.764	432.276	430.082	426.947	422.655	417.040	410.057
	s	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
	v	120.185	75.578	47.548	29.927	18.851	11.886	7.509	4.755	3.024	1.935	1.250	0.817	0.544	0.370	0.258	0.185
	d	0.0083	0.0132	0.0210	0.0334	0.0530	0.0841	0.1332	0.2103	0.3307	0.5168	0.8002	1.2233	1.8383	2.7022	3.8728	5.3959
690.	P	631.109	731.124	820.385	912.718	1032.430	1233.332	1676.285	2686.351	4634.769							
	h	401.809	392.500	382.495	372.173	361.901	352.059	343.607	338.123	336.996							
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40	0.39							
	v	0.137	0.104	0.080	0.061	0.047	0.039	0.034	0.030	0.027							
	d	7.2997	9.6189	12.4981	16.3864	21.1677	25.4624	29.4984	33.6226	37.4429							
700.	P	1.376	2.186	3.473	5.511	8.733	13.810	21.765	34.125	53.078	81.578	123.222	181.662	259.396	355.905	466.624	582.775
	h	441.738	441.706	441.655	441.574	441.447	441.246	440.930	440.433	439.667	438.494	436.738	434.179	430.585	425.753	419.560	412.022
	s	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49	0.48
	v	98.048	61.680	38.811	24.435	15.397	9.715	6.143	3.896	2.483	1.594	1.034	0.681	0.457	0.314	0.222	0.161
	d	0.0102	0.0162	0.0258	0.0409	0.0649	0.1029	0.1628	0.2567	0.4027	0.6273	0.9668	1.4685	2.1884	3.1848	4.5130	6.2125
700.	P	694.446	795.738	893.123	1006.091	1169.818	1477.552	2170.221	3614.679								
	h	403.287	393.650	383.483	373.199	363.108	353.827	346.671	343.220								
	s	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40								
	v	0.120	0.092	0.071	0.054	0.043	0.037	0.032	0.028								
	d	8.3086	10.8578	14.1423	18.5364	23.1983	27.2582	31.3784	35.3975								
710.	P	1.069	1.699	2.700	4.287	6.800	10.769	17.010	26.760	41.839	64.804	98.984	148.214	215.975	303.789	409.866	527.619
	h	447.059	447.035	446.996	446.934	446.836	446.683	446.440	446.058	445.464	444.547	443.156	441.094	438.133	434.045	428.647	421.881
	s	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49
	v	127.297	80.063	50.369	31.698	19.962	12.585	7.946	5.029	3.196	2.042	1.316	0.859	0.569	0.386	0.268	0.191
	d	0.0079	0.0125	0.0199	0.0315	0.0501	0.0795	0.1258	0.1988	0.3129	0.4897	0.7598	1.1647	1.7564	2.5929	3.7350	5.2306
710.	P	647.487	760.769	866.514	978.172	1122.516	1354.598	1828.700	2858.832	4817.616							
	h	413.812	404.661	394.755	384.545	374.334	364.576	356.186	350.696	349.527							
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41	0.40							
	v	0.141	0.106	0.082	0.062	0.048	0.040	0.034	0.030	0.027							
	d	7.1136	9.4101	12.2499	16.0220	20.7190	25.0512	29.0976	33.2259	37.0768							
720.	P	1.320	2.098	3.332	5.289	8.384	13.266	20.925	32.847	51.187	78.895	119.662	177.432	255.226	353.449	468.532	592.397
	h	452.389	452.360	452.313	452.238	452.121	451.936	451.641	451.182	450.470	449.378	447.735	445.327	441.922	437.306	431.336	424.006
	s	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50	0.49
	v	103.966	65.404	41.152	25.905	16.321	10.294	6.505	4.123	2.625	1.683	1.089	0.715	0.478	0.327	0.229	0.166
	d	0.0096	0.0153	0.0243	0.0386	0.0613	0.0971	0.1537	0.2425	0.3809	0.5942	0.9180	1.3988	2.0925	3.0592	4.3575	6.0297
720.	P	715.364	831.438	946.414	1080.686	1271.361	1610.079	2326.713	3781.905								
	h	415.451	405.948	395.883	385.668	375.655	366.454	359.317	355.817								
	s	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41								
	v	0.123	0.094	0.072	0.055	0.044	0.037	0.032	0.029								
	d	8.1021	10.6227	13.8345	18.1110	22.7532	26.8456	30.9616	34.9998								

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																
730.	P	1.024	1.628	2.588	4.110	6.520	10.329	16.325	25.707	40.252	62.486	95.766	144.073	211.286	299.732	408.319	531.680
	h	457.772	457.749	457.713	457.657	457.566	457.424	457.200	456.847	456.295	455.443	454.147	452.215	449.422	445.535	440.366	433.823
	s	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50
	v	135.122	84.980	53.456	33.642	21.183	13.351	8.427	5.331	3.384	2.160	1.389	0.904	0.597	0.403	0.278	0.198
	d	0.0074	0.0118	0.0187	0.0297	0.0472	0.0749	0.1187	0.1876	0.2955	0.4630	0.7197	1.1061	1.6738	2.4823	3.5919	5.0565
730.	P	660.802	786.973	908.650	1039.344	1206.758	1467.225	1968.521	3012.998	4973.505							
	h	425.957	416.961	407.188	397.051	386.924	377.244	368.897	363.378	362.127							
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42	0.41							
	v	0.145	0.109	0.083	0.064	0.049	0.041	0.035	0.030	0.027							
	d	6.9119	9.1847	11.9763	15.6496	20.2520	24.6156	28.6690	32.8	36.6831							
740.	P	1.263	2.008	3.190	5.064	8.031	12.712	20.066	31.536	49.231	76.083	115.841	172.693	250.201	349.580	468.344	599.230
	h	463.163	463.136	463.094	463.024	462.916	462.744	462.473	462.048	461.388	460.373	458.839	456.579	453.361	448.963	443.223	436.115
	s	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51	0.50
	v	110.477	69.490	43.722	27.518	17.334	10.931	6.904	4.373	2.782	1.780	1.150	0.753	0.501	0.341	0.238	0.171
	d	0.0091	0.0144	0.0229	0.0363	0.0577	0.0915	0.1448	0.2287	0.3595	0.5617	0.8696	1.3289	1.9955	2.9307	4.1958	5.8362
740.	P	732.855	863.236	995.365	1149.917	1365.499	1731.939	2468.152	3927.132								
	h	427.757	418.394	408.435	398.303	388.363	379.223	372.081	368.505								
	s	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42								
	v	0.127	0.096	0.074	0.057	0.045	0.038	0.033	0.029								
	d	7.8789	10.3686	13.5091	17.6645	22.2823	26.4062	30.5171	34.5732								
750.	P	0.979	1.557	2.474	3.930	6.236	9.884	15.629	24.632	38.626	60.088	92.378	139.588	205.964	294.492	405.048	533.367
	h	468.605	468.585	468.552	468.500	468.416	468.284	468.077	467.752	467.241	466.451	465.245	463.441	460.815	457.131	452.192	445.879
	s	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51
	v	143.706	90.388	56.857	35.779	22.526	14.193	8.956	5.663	3.592	2.290	1.470	0.954	0.629	0.422	0.290	0.205
	d	0.0070	0.0111	0.0176	0.0279	0.0444	0.0705	0.1117	0.1766	0.2784	0.4367	0.6801	1.0478	1.5909	2.3692	3.4446	4.8753
750.	P	670.942	809.269	946.653	1095.429	1284.694	1570.767	2095.855	3149.209								
	h	438.229	429.419	419.764	409.728	399.668	390.064	381.738	376.165								
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43								
	v	0.149	0.112	0.086	0.066	0.051	0.041	0.035	0.031								
	d	6.6979	8.9380	11.6864	15.2540	19.7652	24.1522	28.2144	32.3461								
760.	P	1.206	1.918	3.047	4.837	7.673	12.152	19.194	30.199	47.224	73.159	111.797	167.507	244.342	344.332	466.076	603.248
	h	474.059	474.033	473.994	473.930	473.830	473.672	473.422	473.030	472.418	471.477	470.048	467.934	464.901	460.723	455.219	448.344
	s	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52	0.51
	v	117.628	73.983	46.546	29.295	18.450	11.631	7.344	4.649	2.954	1.888	1.217	0.794	0.527	0.357	0.248	0.178
	d	0.0085	0.0135	0.0215	0.0341	0.0542	0.0860	0.1362	0.2151	0.3385	0.5296	0.8217	1.2592	1.8978	2.7995	4.0285	5.6330
760.	P	747.055	890.968	1039.611	1213.512	1452.213	1843.315	2594.670	4049.108								
	h	440.182	430.987	421.144	411.090	401.217	392.125	384.965	381.286								
	s	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43								
	v	0.131	0.099	0.076	0.058	0.046	0.039	0.033	0.029								
	d	7.6447	10.0965	13.1646	17.2018	21.7886	25.9435	30.0449	34.1144								
770.	P	0.934	1.485	2.360	3.749	5.951	9.434	14.927	23.545	36.967	57.618	88.841	134.811	200.055	288.220	400.120	532.559
	h	479.558	479.539	479.509	479.461	479.384	479.264	479.072	478.772	478.301	477.571	476.449	474.768	472.306	468.826	464.120	458.047
	s	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52
	v	153.175	96.333	60.596	38.127	24.002	15.122	9.538	6.028	3.821	2.433	1.560	1.010	0.663	0.443	0.304	0.213
	d	0.0065	0.0104	0.0165	0.0262	0.0417	0.0661	0.1048	0.1659	0.2617	0.4110	0.6412	0.9901	1.5080	2.2549	3.2940	4.6865

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																
770.	P	677.948	827.861	979.988	1146.381	1356.133	1665.529	2210.431	3268.080							
	h	450.623	441.999	432.496	422.546	412.560	403.015	394.709	389.058							
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44							
	v	0.154	0.115	0.088	0.067	0.052	0.042	0.036	0.031							
	d	6.4728	8.6794	11.3760	14.8468	19.2592	23.6679	27.7338	31.8647							
780.	P	1.149	1.827	2.903	4.610	7.315	11.588	18.316	28.845	45.174	70.148	107.556	161.924	237.744	337.910	461.791	604.474
	h	485.069	485.047	485.011	484.952	484.861	484.715	484.486	484.123	483.560	482.687	481.360	479.387	476.536	472.575	467.318	460.679
	s	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53	0.52
	v	125.495	78.932	49.658	31.250	19.678	12.402	7.829	4.953	3.144	2.007	1.291	0.840	0.556	0.375	0.259	0.184
	d	0.0080	0.0127	0.0201	0.0320	0.0508	0.0806	0.1277	0.2019	0.3180	0.4983	0.7745	1.1900	1.8	2.6678	3.8567	5.4226
780.	P	757.551	914.533	1079.004	1271.263	1531.185	1943.465	2706.634	4152.420							
	h	452.735	443.714	433.992	424.024	414.214	405.171	397.968	394.159							
	s	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44							
	v	0.135	0.102	0.078	0.060	0.047	0.039	0.034	0.030							
	d	7.3969	9.8095	12.8069	16.7243	21.2710	25.4521	29.5467	33.6306							
790.	P	0.889	1.413	2.246	3.568	5.665	8.983	14.221	22.449	35.288	55.103	85.184	129.780	193.649	281.008	393.569	529.408
	h	490.628	490.610	490.582	490.539	490.469	490.358	490.181	489.905	489.471	488.796	487.760	486.195	483.892	480.612	476.142	470.318
	s	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
	v	163.630	102.887	64.713	40.717	25.629	16.144	10.180	6.431	4.073	2.591	1.659	1.071	0.701	0.467	0.318	0.223
	d	0.0061	0.0097	0.0155	0.0246	0.0390	0.0619	0.0982	0.1555	0.2455	0.3860	0.6029	0.9333	1.4258	2.1404	3.1410	4.4925
790.	P	681.724	842.466	1008.776	1191.836	1420.638	1751.257	2312.597	3369.673							
	h	463.129	454.708	445.362	435.512	425.606	416.107	407.807	402.061							
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45							
	v	0.160	0.119	0.090	0.069	0.053	0.043	0.037	0.032							
	d	6.2388	8.4067	11.0521	14.4245	18.7300	23.1571	27.2287	31.3544							
800.	P	1.092	1.736	2.759	4.383	6.956	11.024	17.434	27.482	43.100	67.070	103.160	156.017	230.482	330.193	455.606	602.913
	h	496.198	496.177	496.144	496.090	496.006	495.873	495.661	495.328	494.809	494.004	492.775	490.937	488.266	484.521	479.511	473.122
	s	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
	v	134.207	84.388	53.087	33.406	21.032	13.254	8.363	5.287	3.354	2.138	1.373	0.891	0.587	0.395	0.272	0.192
	d	0.0075	0.0119	0.0188	0.0299	0.0475	0.0755	0.1196	0.1891	0.2981	0.4677	0.7282	1.1218	1.7026	2.5344	3.6822	5.2050
800.	P	764.458	933.638	1113.206	1322.807	1602.247	2033.492	2804.370	4236.419							
	h	465.404	456.572	446.985	437.105	427.356	418.344	411.092	407.128							
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46	0.45							
	v	0.140	0.105	0.080	0.062	0.048	0.040	0.034	0.030							
	d	7.1385	9.5082	12.4342	16.2320	20.7276	24.9392	29.0224	33.1188							
810.	P	1.342	2.132	3.388	5.380	8.534	13.516	21.351	33.598	52.553	81.450	124.538	186.789	272.906	385.683	523.907	682.286
	h	501.797	501.772	501.731	501.667	501.565	501.402	501.149	500.750	500.129	499.170	497.719	495.571	492.492	488.249	482.686	475.740
	s	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54	0.53
	v	110.120	69.260	43.572	27.423	17.272	10.887	6.875	4.352	2.766	1.768	1.140	0.744	0.494	0.335	0.233	0.167
	d	0.0091	0.0144	0.0230	0.0365	0.0579	0.0918	0.1454	0.2298	0.3616	0.5657	0.8775	1.3444	2.0257	2.9880	4.2941	5.9969
810.	P	852.970	1032.694	1231.542	1478.117	1827.596	2402.722	3455.211								
	h	467.542	458.357	448.623	438.793	429.340	421.033	415.175								
	s	0.52	0.51	0.50	0.49	0.48	0.47	0.46								
	v	0.123	0.093	0.071	0.055	0.044	0.037	0.032								
	d	8.1210	10.7153	13.9891	18.1830	22.6178	26.6999	30.8170								

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-6, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Entropy

Temp.																	
820.	P	1.036	1.647	2.617	4.157	6.599	10.461	16.554	26.117	41.014	63.945	98.649	149.830	222.628	321.394	447.537	598.585
	h	507.442	507.422	507.391	507.342	507.264	507.142	506.948	506.642	506.165	505.423	504.287	502.580	500.082	496.557	491.795	485.665
	s	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54
	v	143.779	90.418	56.874	35.786	22.527	14.193	8.953	5.658	3.586	2.284	1.464	0.948	0.623	0.417	0.285	0.201
	d	0.0070	0.0111	0.0176	0.0279	0.0444	0.0705	0.1117	0.1768	0.2788	0.4379	0.6830	1.0548	1.6061	2.4008	3.5050	4.9816
820.	P	767.666	948.249	1142.135	1367.907	1665.248	2112.947	2888.127	4301.292								
	h	478.188	469.552	460.112	450.328	440.640	431.646	424.338	420.195								
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47	0.46								
	v	0.146	0.109	0.083	0.064	0.050	0.041	0.035	0.031								
	d	6.8699	9.1943	12.0497	15.7263	20.1584	24.4022	28.4723	32.5776								
830.	P	1.271	2.020	3.210	5.097	8.087	12.813	20.254	31.905	49.982	77.645	119.135	179.553	264.060	376.277	516.233	679.663
	h	513.095	513.072	513.036	512.975	512.883	512.736	512.501	512.136	511.565	510.681	509.339	507.340	504.455	500.449	495.140	488.456
	s	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55	0.54
	v	118.100	74.281	46.728	29.406	18.518	11.672	7.367	4.661	2.959	1.889	1.215	0.791	0.523	0.353	0.244	0.174
	d	0.0085	0.0135	0.0214	0.0340	0.0540	0.0857	0.1357	0.2146	0.3380	0.5295	0.8229	1.2644	1.9121	2.8331	4.0934	5.7476
830.	P	859.380	1051.616	1265.374	1528.397	1894.751	2480.243	3525.157									
	h	480.482	471.485	461.872	452.118	442.709	434.391	428.399									
	s	0.53	0.52	0.51	0.50	0.49	0.48	0.47									
	v	0.128	0.096	0.074	0.057	0.045	0.038	0.033									
	d	7.8263	10.3647	13.5430	17.6196	22.0511	26.1445	30.2535									
840.	P	0.980	1.558	2.476	3.933	6.245	9.904	15.680	24.756	38.923	60.800	94.050	143.405	214.282	311.593	437.775	591.623
	h	518.795	518.776	518.748	518.703	518.633	518.522	518.343	518.063	517.625	516.942	515.895	514.314	511.987	508.676	504.165	498.297
	s	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55
	v	154.364	97.071	61.058	38.416	24.180	15.232	9.605	6.067	3.843	2.445	1.565	1.011	0.662	0.441	0.301	0.210
	d	0.0065	0.0103	0.0164	0.0260	0.0414	0.0656	0.1041	0.1648	0.2602	0.4091	0.6391	0.9891	1.5110	2.2678	3.3269	4.7546
840.	P	767.263	958.227	1165.540	1406.582	1719.974	2181.885	2957.777	4348.591								
	h	491.071	482.652	473.371	463.681	454.063	445.083	437.709	433.368								
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48	0.47								
	v	0.152	0.113	0.086	0.066	0.051	0.042	0.036	0.031								
	d	6.5942	8.8685	11.6536	15.2129	19.5643	23.8379	27.8956	32.0071								
850.	P	1.201	1.908	3.033	4.817	7.645	12.118	19.168	30.220	47.408	73.811	113.612	172.020	254.553	365.622	506.385	673.885
	h	524.504	524.484	524.449	524.396	524.311	524.174	523.962	523.627	523.101	522.289	521.049	519.196	516.504	512.731	507.686	501.266
	s	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.58	0.57	0.56	0.55
	v	126.931	79.836	50.219	31.603	19.897	12.537	7.911	5.002	3.173	2.023	1.299	0.843	0.556	0.373	0.257	0.182
	d	0.0079	0.0125	0.0199	0.0316	0.0503	0.0798	0.1264	0.1999	0.3152	0.4944	0.7698	1.1860	1.7998	2.6785	3.8898	5.4928
850.	P	861.655	1065.525	1293.152	1571.121	1952.697	2546.770	3578.721									
	h	493.535	484.727	475.251	465.587	456.212	447.869	441.745									
	s	0.54	0.53	0.52	0.51	0.50	0.49	0.48									
	v	0.133	0.100	0.076	0.059	0.047	0.039	0.034									
	d	7.5212	10.0047	13.0881	17.0377	21.4562	25.5694	29.6586									

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
2	T	60.078	72.402	84.524	96.465	108.238	119.852		177.594	192.844	207.771	222.396	236.741	250.824	264.663	278.268	291.655
	h	0.	5.	10.	15.	20.	25.	Phase	215.	220.	225.	230.	235.	240.	245.	250.	255.
	s	0.00009	0.00959	0.01888	0.02797	0.03687	0.04558		0.36824	0.37599	0.38357	0.39098	0.39823	0.40534	0.41231	0.41915	0.42586
	v	0.018	0.018	0.019	0.019	0.019	0.019	Change	36.833	37.735	38.617	39.479	40.324	41.153	41.968	42.768	43.556
	d	54.4992	54.0976	53.6990	53.3032	52.9099	52.5189		0.0271	0.0265	0.0259	0.0253	0.0248	0.0243	0.0238	0.0234	0.0230
2	T	304.837	317.825	330.624	343.253	355.712	368.014	380.163	392.166	404.033	415.766	427.375	438.859	450.230	461.485	472.632	483.674
	h	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.	320.	325.	330.	335.
	s	0.43246	0.43894	0.44532	0.45160	0.45778	0.46387	0.46986	0.47577	0.48160	0.48735	0.49303	0.49863	0.50416	0.50962	0.51501	0.52034
	v	44.329	45.090	45.844	46.583	47.313	48.033	48.745	49.451	50.142	50.832	51.510	52.183	52.846	53.505	54.157	54.805
	d	0.0226	0.0222	0.0218	0.0215	0.0211	0.0208	0.0205	0.0202	0.0199	0.0197	0.0194	0.0192	0.0189	0.0187	0.0185	0.0182
2	T	494.619	505.465	516.217	526.881	537.458	547.947	558.357	568.687	578.942	589.122	599.228	609.264	619.234	629.139	638.978	648.755
	h	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.
	s	0.52561	0.53082	0.53598	0.54107	0.54611	0.55110	0.55604	0.56092	0.56576	0.57055	0.57530	0.58	0.58465	0.58927	0.59384	0.59837
	v	55.442	56.077	56.705	57.327	57.945	58.559	59.167	59.770	60.366	60.960	61.552	62.139	62.720	63.298	63.873	64.443
	d	0.0180	0.0178	0.0176	0.0174	0.0173	0.0171	0.0169	0.0167	0.0166	0.0164	0.0162	0.0161	0.0159	0.0158	0.0157	0.0155
2	T	658.472	668.127	677.727	687.270	696.761	706.196	715.584	724.918	734.201	743.438	752.626	761.770	770.868	779.927	788.940	797.908
	h	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.
	s	0.60286	0.60731	0.61173	0.61610	0.62045	0.62475	0.62902	0.63326	0.63747	0.64164	0.64578	0.64989	0.65397	0.65801	0.66203	0.66602
	v	65.009	65.572	66.134	66.693	67.244	67.796	68.340	68.884	69.428	69.965	70.504	71.036	71.568	72.093	72.618	73.143
	d	0.0154	0.0153	0.0151	0.0150	0.0149	0.0148	0.0146	0.0145	0.0144	0.0143	0.0142	0.0141	0.0140	0.0139	0.0138	0.0137
2	T	806.839	815.729	824.580	833.394	842.168	850.907	859.611									
	h	500.	505.	510.	515.	520.	525.	530.									
	s	0.66998	0.67392	0.67783	0.68171	0.68556	0.68939	0.69319									
	v	73.662	74.180	74.698	75.212	75.724	76.232	76.738									
	d	0.0136	0.0135	0.0134	0.0133	0.0132	0.0131	0.0130									
5	T	60.064	72.385	84.508	96.451	108.222	119.837	131.302	142.631	153.824	164.894		265.636	279.182	292.517	305.651	318.594
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	Phase	245.	250.	255.	260.	265.
	s	0.00007	0.00957	0.01887	0.02795	0.03685	0.04557	0.05411	0.06249	0.07071	0.07879		0.39271	0.39954	0.40625	0.41284	0.41931
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	Change	16.697	17.020	17.339	17.651	17.959
	d	54.5007	54.0991	53.7006	53.3047	52.9116	52.5205	52.1315	51.7444	51.3589	50.9743		0.0599	0.0588	0.0577	0.0567	0.0557
5	T	331.354	343.944	356.370	368.641	380.761	392.740	404.581	416.292	427.878	439.343	450.694	461.934	473.065	484.093	495.019	505.852
	h	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.	320.	325.	330.	335.	340.	345.
	s	0.42569	0.43196	0.43813	0.44421	0.45021	0.45611	0.46194	0.46769	0.47336	0.47895	0.48448	0.48994	0.49533	0.50066	0.50593	0.51114
	v	18.263	18.561	18.856	19.146	19.433	19.716	19.997	20.273	20.546	20.817	21.084	21.349	21.611	21.871	22.129	22.383
	d	0.0548	0.0539	0.0530	0.0522	0.0515	0.0507	0.0500	0.0493	0.0487	0.0480	0.0474	0.0468	0.0463	0.0457	0.0452	0.0447
5	T	516.593	527.244	537.807	548.289	558.686	569.008	579.252	589.422	599.521	609.549	619.511	629.406	639.240	649.008	658.720	668.370
	h	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.
	s	0.51629	0.52138	0.52642	0.53141	0.53634	0.54123	0.54606	0.55085	0.55559	0.56029	0.56495	0.56956	0.57413	0.57866	0.58315	0.58760
	v	22.635	22.886	23.134	23.380	23.625	23.866	24.107	24.345	24.582	24.819	25.051	25.284	25.513	25.744	25.970	26.197
	d	0.0442	0.0437	0.0432	0.0428	0.0423	0.0419	0.0415	0.0411	0.0407	0.0403	0.0399	0.0396	0.0392	0.0388	0.0385	0.0382
5	T	677.963	687.502	696.986	706.415	715.798	725.124	734.406	743.640	752.823	761.961	771.060	780.111	789.118	798.088	807.014	815.900
	h	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.
	s	0.59201	0.59639	0.60073	0.60504	0.60931	0.61355	0.61775	0.62192	0.62606	0.63017	0.63425	0.63829	0.64231	0.64630	0.65026	0.65420
	v	26.422	26.645	26.867	27.089	27.306	27.527	27.742	27.959	28.175	28.388	28.600	28.812	29.024	29.232	29.441	29.649
	d	0.0378	0.0375	0.0372	0.0369	0.0366	0.0363	0.0360	0.0358	0.0355	0.0352	0.0350	0.0347	0.0345	0.0342	0.0340	0.0337

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																	
5	T	824.747	833.557	842.327	851.065	859.763											
	h	510.	515.	520.	525.	530.											
	s	0.65810	0.66198	0.66584	0.66966	0.67346											
	v	29.857	30.061	30.268	30.471	30.674											
	d	0.0335	0.0333	0.0330	0.0328	0.0326											
10	T	60.034	72.356	84.482	96.424	108.198	119.812	131.280	142.605	153.802	164.870	175.823	186.660	197.385		239.714	253.603
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	Phase	235.	240.
	s	0.00003	0.00954	0.01883	0.02792	0.03682	0.04554	0.05408	0.06246	0.07068	0.07876	0.08670	0.09450	0.10217		0.36399	0.37107
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	Change	7.933	8.104
	d	54.5033	54.1017	53.7032	53.3074	52.9142	52.5232	52.1344	51.7475	51.3620	50.9777	50.5948	50.2127	49.8316		0.1261	0.1234
10	T	267.265	280.715	293.960	307.010	319.880	332.575	345.104	357.475	369.690	381.764	393.697	405.498	417.170	428.720	440.153	451.469
	h	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.	320.
	s	0.37801	0.38483	0.39152	0.39810	0.40457	0.41093	0.41719	0.42336	0.42943	0.43542	0.44132	0.44714	0.45288	0.45854	0.46413	0.46965
	v	8.273	8.437	8.599	8.759	8.915	9.069	9.220	9.369	9.517	9.662	9.805	9.947	10.087	10.225	10.361	10.496
	d	0.1209	0.1185	0.1163	0.1142	0.1122	0.1103	0.1085	0.1067	0.1051	0.1035	0.1020	0.1005	0.0991	0.0978	0.0965	0.0953
10	T	462.679	473.783	484.785	495.689	506.502	517.217	527.848	538.393	548.855	559.237	569.540	579.769	589.923	600.007	610.024	619.974
	h	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.
	s	0.47511	0.48050	0.48582	0.49109	0.49629	0.50144	0.50653	0.51156	0.51655	0.52148	0.52636	0.53120	0.53598	0.54072	0.54542	0.55007
	v	10.630	10.763	10.894	11.023	11.152	11.279	11.405	11.530	11.654	11.777	11.899	12.020	12.140	12.260	12.377	12.495
	d	0.0941	0.0929	0.0918	0.0907	0.0897	0.0887	0.0877	0.0867	0.0858	0.0849	0.0840	0.0832	0.0824	0.0816	0.0808	0.0800
10	T	629.856	639.676	649.437	659.133	668.776	678.358	687.888	697.363	706.785	716.155	725.477	734.748	743.973	753.152	762.284	771.372
	h	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.
	s	0.55468	0.55925	0.56378	0.56827	0.57272	0.57713	0.58151	0.58585	0.59015	0.59442	0.59865	0.60286	0.60703	0.61116	0.61527	0.61935
	v	12.612	12.728	12.843	12.958	13.071	13.184	13.296	13.408	13.519	13.629	13.739	13.848	13.956	14.064	14.172	14.278
	d	0.0793	0.0786	0.0779	0.0772	0.0765	0.0758	0.0752	0.0746	0.0740	0.0734	0.0728	0.0722	0.0717	0.0711	0.0706	0.0700
10	T	780.416	789.418	798.378	807.303	816.181	825.024	833.828	842.596	851.327	860.021						
	h	485.	490.	495.	500.	505.	510.	515.	520.	525.	530.						
	s	0.62340	0.62741	0.63140	0.63536	0.63929	0.64320	0.64708	0.65093	0.65476	0.65856						
	v	14.385	14.491	14.597	14.701	14.805	14.909	15.013	15.115	15.217	15.320						
	d	0.0695	0.0690	0.0685	0.0680	0.0675	0.0671	0.0666	0.0662	0.0657	0.0653						
20	T	59.977	72.302	84.427	96.371	108.146	119.762	131.230	142.557	153.755	164.826	175.779	186.616	197.343	207.965	218.485	228.904
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00004	0.00947	0.01877	0.02786	0.03676	0.04547	0.05402	0.06240	0.07062	0.07870	0.08664	0.09444	0.10211	0.10966	0.11709	0.12441
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.021
	d	54.5083	54.1069	53.7085	53.3129	52.9199	52.5292	52.1404	51.7533	51.3683	50.9842	50.6013	50.2196	49.8388	49.4583	49.0778	48.6979
20	T	239.229	249.457		296.877	309.763	322.484	335.040	347.443	359.699	371.808	383.784	395.627	407.341	418.938	430.418	441.780
	h	80.	85.	Phase	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.13162	0.13872		0.37701	0.38356	0.39001	0.39635	0.40259	0.40874	0.41480	0.42077	0.42666	0.43246	0.43819	0.44385	0.44943
	v	0.021	0.021	Change	4.229	4.311	4.392	4.471	4.549	4.626	4.702	4.776	4.850	4.922	4.993	5.064	5.134
	d	48.3174	47.9369		0.2365	0.2320	0.2277	0.2236	0.2198	0.2162	0.2127	0.2094	0.2062	0.2032	0.2003	0.1975	0.1948
20	T	453.032	464.182	475.231	486.182	497.037	507.800	518.476	529.062	539.568	549.992	560.338	570.610	580.806	590.933	600.985	610.975
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.45494	0.46039	0.46577	0.47108	0.47634	0.48154	0.48668	0.49176	0.49679	0.50177	0.50669	0.51157	0.51640	0.52118	0.52592	0.53061
	v	5.203	5.271	5.338	5.405	5.471	5.536	5.601	5.665	5.728	5.791	5.854	5.915	5.977	6.037	6.098	6.158
	d	0.1922	0.1897	0.1873	0.1850	0.1828	0.1806	0.1786	0.1765	0.1746	0.1727	0.1708	0.1691	0.1673	0.1656	0.1640	0.1624

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
20	T	620.898	630.757	640.554	650.289	659.967	669.585	679.152	688.659	698.116	707.521	716.875	726.178	735.436	744.645	753.808	762.927
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.53526	0.53987	0.54443	0.54895	0.55344	0.55789	0.56230	0.56667	0.57101	0.57531	0.57957	0.58381	0.58801	0.59217	0.59631	0.60042
	v	6.217	6.276	6.335	6.393	6.451	6.508	6.565	6.622	6.678	6.734	6.790	6.846	6.901	6.955	7.010	7.064
	d	0.1608	0.1593	0.1579	0.1564	0.1550	0.1536	0.1523	0.1510	0.1497	0.1485	0.1473	0.1461	0.1449	0.1438	0.1427	0.1416
20	T	772.	781.033	790.022	798.971	807.880	816.751	825.582	834.373	843.132	851.852	860.538					
	h	480.	485.	490.	495.	500.	505.	510.	515.	520.	525.	530.					
	s	0.60449	0.60853	0.61255	0.61654	0.62049	0.62443	0.62833	0.63221	0.63606	0.63988	0.64368					
	v	7.118	7.171	7.225	7.277	7.331	7.383	7.435	7.487	7.539	7.591	7.642					
	d	0.1405	0.1395	0.1384	0.1374	0.1364	0.1354	0.1345	0.1336	0.1326	0.1317	0.1309					
50	T	59.806	72.134	84.263	96.214	107.989	119.610	131.084	142.416	153.615	164.690	175.646	186.488	197.218	207.842	218.366	228.792
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00024	0.00928	0.01857	0.02767	0.03656	0.04528	0.05383	0.06221	0.07044	0.07852	0.08646	0.09427	0.10194	0.10949	0.11692	0.12424
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.021
	d	54.5234	54.1224	53.7244	53.3292	52.9368	52.5464	52.1580	51.7716	51.3871	51.0035	50.6213	50.2400	49.8599	49.4800	49.1007	48.7214
50	T	239.118	249.353	259.494	269.548	279.512	289.394	299.187	308.894	318.522		330.518	342.641	354.644	366.535	378.313	389.976
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	Phase	265.	270.	275.	280.	285.	290.
	s	0.13145	0.13855	0.14555	0.15246	0.15927	0.16599	0.17262	0.17917	0.18563		0.37141	0.37769	0.38387	0.38997	0.39598	0.40190
	v	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	Change	1.676	1.711	1.745	1.778	1.811	1.843
	d	48.3420	47.9623	47.5820	47.2008	46.8187	46.4353	46.0500	45.6630	45.2740		0.5967	0.5846	0.5731	0.5624	0.5522	0.5426
50	T	401.539	412.993	424.341	435.592	446.743	457.803	468.766	479.642	490.429	501.132	511.750	522.289	532.752	543.136	553.445	563.686
	h	295.	300.	305.	310.	315.	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.
	s	0.40775	0.41351	0.41921	0.42483	0.43038	0.43586	0.44128	0.44663	0.45192	0.45716	0.46233	0.46745	0.47252	0.47753	0.48249	0.48740
	v	1.875	1.906	1.936	1.966	1.996	2.025	2.054	2.083	2.111	2.139	2.166	2.193	2.220	2.247	2.273	2.299
	d	0.5334	0.5247	0.5164	0.5085	0.5010	0.4937	0.4868	0.4801	0.4737	0.4676	0.4617	0.4559	0.4504	0.4451	0.4400	0.4350
50	T	573.853	583.953	593.984	603.951	613.857	623.698	633.480	643.206	652.871	662.482	672.037	681.541	690.992	700.390	709.739	719.042
	h	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.
	s	0.49226	0.49708	0.50184	0.50657	0.51125	0.51588	0.52048	0.52503	0.52954	0.53402	0.53846	0.54286	0.54722	0.55155	0.55584	0.56010
	v	2.325	2.350	2.376	2.401	2.425	2.450	2.475	2.499	2.523	2.547	2.570	2.594	2.617	2.641	2.664	2.687
	d	0.4302	0.4255	0.4210	0.4166	0.4123	0.4081	0.4041	0.4002	0.3964	0.3927	0.3890	0.3855	0.3821	0.3787	0.3754	0.3722
50	T	728.299	737.504	746.669	755.787	764.866	773.897	782.888	791.842	800.752	809.625	818.457	827.258	836.018	844.743	853.433	862.090
	h	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.	520.	525.	530.
	s	0.56432	0.56852	0.57268	0.57681	0.58090	0.58497	0.58901	0.59302	0.59700	0.60095	0.60488	0.60878	0.61265	0.61650	0.62032	0.62411
	v	2.709	2.732	2.754	2.777	2.799	2.821	2.843	2.865	2.887	2.908	2.930	2.951	2.972	2.994	3.015	3.036
	d	0.3691	0.3660	0.3630	0.3601	0.3573	0.3545	0.3517	0.3491	0.3464	0.3439	0.3413	0.3389	0.3364	0.3341	0.3317	0.3294
100	T	59.519	71.857	83.993	95.949	107.731	119.360	130.835	142.176	153.383	164.465	175.425	186.271	197.007	207.641	218.168	228.601
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00057	0.00895	0.01825	0.02734	0.03625	0.04497	0.05352	0.06191	0.07014	0.07822	0.08616	0.09397	0.10165	0.10920	0.11663	0.12395
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.021
	d	54.5484	54.1480	53.7508	53.3562	52.9647	52.5749	52.1876	51.8020	51.4182	51.0357	50.6546	50.2746	49.8953	49.5165	49.1382	48.7602
100	T	238.935	249.175	259.324	269.385	279.356	289.246	299.045	308.768	318.402	327.956	337.429	346.821	356.129	365.358	374.508	383.571
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.13117	0.13827	0.14527	0.15218	0.15899	0.16571	0.17234	0.17889	0.18536	0.19175	0.19806	0.20429	0.21046	0.21655	0.22258	0.22854
	v	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023	0.024
	d	48.3822	48.0038	47.6254	47.2458	46.8653	46.4837	46.1003	45.7158	45.3288	44.9392	44.5467	44.1516	43.7520	43.3487	42.9410	42.5279

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7. Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
100	T		389.763	400.851	411.879	422.840	433.741	444.575	455.340	466.044	476.675	487.234	497.733	508.163	518.528	528.827	539.057
	h	Phase	285.	290.	295.	300.	305.	310.	315.	320.	325.	330.	335.	340.	345.	350.	355.
	s		0.38259	0.38844	0.39421	0.39992	0.40555	0.41111	0.41661	0.42204	0.42741	0.43272	0.43797	0.44316	0.44830	0.45339	0.45842
	v	Change	0.844	0.863	0.881	0.898	0.915	0.932	0.949	0.965	0.981	0.996	1.012	1.027	1.042	1.057	1.071
	d		1.1844	1.1593	1.1356	1.1134	1.0925	1.0728	1.0541	1.0365	1.0197	1.0036	0.9884	0.9738	0.9598	0.9464	0.9336
100	T	549.230	559.340	569.389	579.377	589.303	599.172	608.987	618.744	628.449	638.100	647.695	657.240	666.736	676.183	685.578	694.926
	h	360.	365.	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.
	s	0.46340	0.46833	0.47321	0.47805	0.48284	0.48758	0.49228	0.49694	0.50156	0.50613	0.51067	0.51516	0.51962	0.52404	0.52842	0.53277
	v	1.085	1.100	1.114	1.127	1.141	1.155	1.168	1.181	1.194	1.207	1.220	1.233	1.245	1.258	1.270	1.282
	d	0.9213	0.9094	0.8980	0.8870	0.8764	0.8661	0.8563	0.8467	0.8374	0.8284	0.8197	0.8113	0.8030	0.7951	0.7873	0.7798
100	T	704.229	713.487	722.699	731.867	740.993	750.078	759.121	768.122	777.088	786.010	794.893	803.742	812.552	821.328	830.068	838.773
	h	440.	445.	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.
	s	0.53709	0.54136	0.54561	0.54982	0.55400	0.55815	0.56227	0.56636	0.57041	0.57444	0.57844	0.58241	0.58636	0.59027	0.59416	0.59803
	v	1.295	1.307	1.319	1.331	1.342	1.354	1.366	1.377	1.389	1.400	1.412	1.423	1.434	1.445	1.457	1.468
	d	0.7724	0.7653	0.7583	0.7515	0.7449	0.7385	0.7322	0.7260	0.7200	0.7141	0.7084	0.7027	0.6972	0.6918	0.6866	0.6814
100	T	847.447	856.084														
	h	520.	525.														
	s	0.60187	0.60568														
	v	1.478	1.489														
	d	0.6764	0.6714														
200	T	58.947	71.299	83.450	95.418	107.216	118.855	130.344	141.695	152.914	164.006	174.981	185.837	196.587	207.230	217.772	228.216
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00124	0.00829	0.01760	0.02670	0.03561	0.04434	0.05290	0.06129	0.06953	0.07762	0.08557	0.09338	0.10106	0.10862	0.11606	0.12338
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.5983	54.1990	53.8031	53.4102	53.0199	52.6318	52.2461	51.8624	51.4803	51.0998	50.7205	50.3427	49.9654	49.5892	49.2131	48.8379
200	T	238.563	248.818	258.982	269.053	279.043	288.947	298.763	308.500	318.154	327.729	337.220	346.634	355.970	365.222	374.398	383.485
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.13060	0.13771	0.14471	0.15162	0.15844	0.16516	0.17180	0.17835	0.18481	0.19120	0.19752	0.20375	0.20992	0.21602	0.22204	0.22800
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023	0.023
	d	48.4626	48.0870	47.7114	47.3346	46.9579	46.5800	46.2002	45.8195	45.4367	45.0517	44.6641	44.2744	43.8809	43.4836	43.0827	42.6767
200	T	392.500	401.433	410.277	419.037	427.718	436.302	444.793	453.181		474.201	484.	493.802	503.612	513.406	523.187	532.951
	h	160.	165.	170.	175.	180.	185.	190.	195.	Phase	315.	320.	325.	330.	335.	340.	345.
	s	0.23390	0.23974	0.24552	0.25123	0.25690	0.26251	0.26806	0.27356		0.40405	0.40937	0.41464	0.41986	0.42503	0.43014	0.43520
	v	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.026	Change	0.421	0.431	0.441	0.451	0.460	0.469	0.478
	d	42.2654	41.8497	41.4203	40.9650	40.4995	40.0222	39.5325	39.0284		2.3753	2.3197	2.2678	2.2197	2.1746	2.1324	2.0927
200	T	542.687	552.399	562.080	571.727	581.346	590.931	600.476	609.986	619.458	628.893	638.289	647.649	656.969	666.251	675.495	684.704
	h	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.
	s	0.44021	0.44518	0.45010	0.45497	0.45979	0.46457	0.46931	0.47401	0.47866	0.48327	0.48785	0.49238	0.49688	0.50134	0.50576	0.51015
	v	0.487	0.495	0.503	0.512	0.520	0.528	0.536	0.543	0.551	0.558	0.566	0.573	0.580	0.587	0.594	0.601
	d	2.0552	2.0198	1.9862	1.9542	1.9240	1.8950	1.8673	1.8409	1.8156	1.7913	1.7678	1.7455	1.7238	1.7030	1.6829	1.6635
200	T	693.872	703.006	712.099	721.157	730.181	739.166	748.117	757.033	765.911	774.762	783.572	792.353	801.100	809.816	818.500	827.150
	h	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.
	s	0.51450	0.51882	0.52310	0.52735	0.53157	0.53575	0.53991	0.54403	0.54813	0.55219	0.55623	0.56024	0.56422	0.56817	0.57209	0.57599
	v	0.608	0.615	0.621	0.628	0.635	0.641	0.648	0.654	0.660	0.667	0.673	0.679	0.685	0.691	0.697	0.703
	d	1.6448	1.6266	1.6091	1.5921	1.5756	1.5595	1.5440	1.5289	1.5142	1.5	1.4860	1.4725	1.4593	1.4465	1.4340	1.4217

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
200	T	835.771	844.359	852.920	861.451											
	h	510.	515.	520.	525.											
	s	0.57987	0.58371	0.58753	0.59133											
	v	0.709	0.715	0.721	0.727											
	d	1.4098	1.3981	1.3867	1.3756											
300	T	58.373	70.739	82.904	94.885	106.697	118.348	129.850	141.211	152.442	163.544	174.532	185.403	196.162	206.819	217.372	227.828
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00192	0.00762	0.01694	0.02606	0.03498	0.04372	0.05228	0.06068	0.06893	0.07702	0.08498	0.09279	0.10048	0.10804	0.11548	0.12281
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.6478	54.2501	53.8553	53.4638	53.0748	52.6884	52.3043	51.9221	51.5419	51.1631	50.7857	50.4099	50.0349	49.6606	49.2874	48.9142
300	T	238.189	248.456	258.633	268.720	278.725	288.640	298.475	308.229	317.899	327.493	337.005	346.439	355.792	365.068	374.266	383.389
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.13003	0.13714	0.14416	0.15107	0.15789	0.16461	0.17125	0.17780	0.18427	0.19066	0.19698	0.20322	0.20938	0.21548	0.22151	0.22747
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023	0.023
	d	48.5416	48.1687	47.7959	47.4225	47.0489	46.6743	46.2982	45.9215	45.5430	45.1623	44.7796	44.3943	44.0063	43.6151	43.2197	42.8211
300	T	392.430	401.392	410.273	419.074	427.787	436.418	444.966	453.414	461.771	470.019	478.177	486.210	494.124	501.896	509.528	
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	Phase
	s	0.23337	0.23921	0.24499	0.25070	0.25637	0.26197	0.26753	0.27303	0.27848	0.28388	0.28924	0.29454	0.29981	0.30503	0.31021	
	v	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.028	0.028	Change
	d	42.4181	42.0086	41.5907	41.1540	40.7068	40.2503	39.7853	39.3065	38.8160	38.3110	37.7930	37.2565	36.7016	36.1252	35.5260	
300	T	513.645	522.319	531.114	539.996	548.950	557.950	566.984	576.046	585.122	594.210	603.303	612.389	621.471	630.543	639.604	648.646
	h	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.
	s	0.40815	0.41327	0.41834	0.42336	0.42834	0.43328	0.43817	0.44302	0.44782	0.45259	0.45731	0.46199	0.46664	0.47125	0.47581	0.48034
	v	0.257	0.265	0.273	0.281	0.288	0.295	0.302	0.308	0.315	0.321	0.327	0.333	0.339	0.345	0.350	0.356
	d	3.8875	3.7688	3.6619	3.5642	3.4752	3.3928	3.3165	3.2455	3.1791	3.1170	3.0588	3.0038	2.9517	2.9024	2.8557	2.8112
300	T	657.672	666.678	675.659	684.628	693.566	702.481	711.375	720.238	729.078	737.889	746.678	755.438	764.172	772.875	781.558	790.210
	h	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.
	s	0.48484	0.48929	0.49371	0.49810	0.50245	0.50677	0.51106	0.51531	0.51953	0.52372	0.52788	0.53201	0.53611	0.54018	0.54423	0.54824
	v	0.361	0.367	0.372	0.377	0.382	0.387	0.392	0.397	0.402	0.407	0.411	0.416	0.421	0.425	0.430	0.434
	d	2.7687	2.7283	2.6894	2.6526	2.6169	2.5827	2.5501	2.5184	2.4880	2.4586	2.4303	2.4029	2.3764	2.3507	2.3261	2.3019
300	T	798.838	807.435	816.005	824.554	833.075	841.567	850.035	858.477								
	h	485.	490.	495.	500.	505.	510.	515.	520.								
	s	0.55223	0.55619	0.56012	0.56403	0.56791	0.57176	0.57559	0.57940								
	v	0.439	0.443	0.448	0.452	0.456	0.461	0.465	0.469								
	d	2.2786	2.2560	2.2339	2.2126	2.1917	2.1714	2.1517	2.1325								
400	T	57.798	70.177	82.356	94.351	106.175	117.839	129.352	140.728	151.967	163.084	174.080	184.961	195.736	206.401	216.969	227.435
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00259	0.00696	0.01629	0.02542	0.03435	0.04309	0.05166	0.06007	0.06832	0.07642	0.08438	0.09220	0.09990	0.10746	0.11491	0.12224
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.6970	54.3006	53.9073	53.5169	53.1293	52.7445	52.3619	51.9814	51.6029	51.2258	50.8507	50.4766	50.1035	49.7318	49.3603	48.9899
400	T	237.806	248.086	258.279	268.379	278.396	288.329	298.179	307.948	317.636	327.245	336.775	346.227	355.608	364.905	374.123	383.274
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12947	0.13658	0.14360	0.15051	0.15733	0.16406	0.17070	0.17726	0.18373	0.19012	0.19644	0.20268	0.20885	0.21495	0.22098	0.22694
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023
	d	48.6193	48.2495	47.8792	47.5090	47.1380	46.7667	46.3944	46.0214	45.6463	45.2706	44.8919	44.5112	44.1288	43.7428	43.3532	42.9613

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
400	T	392.342	401.334	410.246	419.081	427.833	436.503	445.098	453.599	462.007	470.327	478.550	486.672	494.677	502.570	510.330	517.958
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23284	0.23868	0.24446	0.25018	0.25584	0.26144	0.26700	0.27250	0.27795	0.28335	0.28870	0.29401	0.29927	0.30448	0.30966	0.31480
	v	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.027	0.028	0.028
	d	42.5645	42.1639	41.7546	41.3301	40.8976	40.4565	40.0076	39.5482	39.0781	38.5957	38.1007	37.5926	37.0666	36.5247	35.9625	35.3795
400	T	525.425	532.716	539.796	546.619		552.155	559.580	567.284	575.204	583.290	591.511	599.831	608.231	616.697	625.216	633.770
	h	240.	245.	250.	255.	Phase	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.
	s	0.31989	0.32495	0.32997	0.33495		0.41425	0.41918	0.42407	0.42891	0.43373	0.43850	0.44324	0.44794	0.45261	0.45723	0.46182
	v	0.029	0.029	0.030	0.031	Change	0.177	0.184	0.191	0.197	0.203	0.209	0.215	0.221	0.226	0.231	0.236
	d	34.7719	34.1350	33.4632	32.7532		5.6527	5.4328	5.2398	5.0687	4.9152	4.7764	4.6496	4.5335	4.4261	4.3271	4.2344
400	T	642.359	650.968	659.595	668.231	676.872	685.516	694.157	702.797	711.424	720.049	728.658	737.253	745.839	754.407	762.959	771.496
	h	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.
	s	0.46638	0.47090	0.47538	0.47983	0.48425	0.48863	0.49298	0.49730	0.50158	0.50584	0.51006	0.51425	0.51842	0.52255	0.52665	0.53073
	v	0.241	0.246	0.251	0.255	0.260	0.264	0.268	0.273	0.277	0.281	0.285	0.289	0.293	0.297	0.301	0.304
	d	4.1482	4.0671	3.9911	3.9193	3.8514	3.7871	3.7260	3.6681	3.6125	3.5599	3.5093	3.4608	3.4144	3.3699	3.3272	3.2859
400	T	780.013	788.510	796.992	805.452	813.893	822.313	830.715	839.095	847.452	855.791						
	h	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.						
	s	0.53478	0.53879	0.54279	0.54675	0.55069	0.55460	0.55849	0.56235	0.56619	0.57						
	v	0.308	0.312	0.315	0.319	0.323	0.326	0.330	0.333	0.336	0.340						
	d	3.2461	3.2078	3.1709	3.1352	3.1006	3.0672	3.0349	3.0034	2.9730	2.9433						
500	T	57.219	69.615	81.808	93.816	105.651	117.327	128.854	140.240	151.493	162.618	173.627	184.522	195.304	205.981	216.559	227.041
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00326	0.00630	0.01564	0.02477	0.03371	0.04246	0.05105	0.05946	0.06772	0.07582	0.08379	0.09162	0.09931	0.10688	0.11434	0.12168
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.7461	54.3508	53.9587	53.5697	53.1837	52.8003	52.4190	52.0402	51.6632	51.2880	50.9146	50.5423	50.1714	49.8018	49.4328	49.0643
500	T	237.423	247.718	257.921	268.035	278.065	288.009	297.877	307.658	317.364	326.989	336.539	346.011	355.406	364.725	373.974	383.138
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12890	0.13602	0.14304	0.14996	0.15678	0.16351	0.17016	0.17672	0.18319	0.18959	0.19591	0.20215	0.20832	0.21442	0.22045	0.22641
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023
	d	48.6966	48.3290	47.9616	47.5939	47.2264	46.8579	46.4893	46.1192	45.7484	45.3762	45.0019	44.6264	44.2482	43.8670	43.4844	43.0974
500	T	392.236	401.255	410.198	419.063	427.853	436.563	445.192	453.742	462.201	470.581	478.864	487.057	495.144	503.129	511.002	518.750
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23231	0.23815	0.24393	0.24965	0.25531	0.26092	0.26647	0.27197	0.27742	0.28282	0.28817	0.29347	0.29873	0.30394	0.30912	0.31425
	v	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.028	0.028
	d	42.7072	42.3135	41.9119	41.4985	41.0772	40.6494	40.2142	39.7694	39.3154	38.8520	38.3768	37.8900	37.3888	36.8731	36.3417	35.7917
500	T	526.380	533.852	541.148	548.278	555.167	561.796	568.103	574.010	579.313		583.426	589.024	595.237	601.900	608.910	616.184
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	Phase	340.	345.	350.	355.	360.	365.
	s	0.31934	0.32439	0.32940	0.33438	0.33933	0.34424	0.34912	0.35397	0.35879		0.41647	0.42124	0.42600	0.43072	0.43541	0.44008
	v	0.028	0.029	0.029	0.030	0.031	0.031	0.032	0.033	0.034	Change	0.124	0.131	0.138	0.144	0.149	0.155
	d	35.2240	34.6311	34.0111	33.3650	32.6815	31.9578	31.1844	30.3543	29.4288		8.0369	7.6144	7.2591	6.9546	6.6899	6.4553
500	T	623.669	631.320	639.104	647.009	655.	663.062	671.189	679.369	687.582	695.831	704.106	712.398	720.706	729.029	737.356	745.686
	h	370.	375.	380.	385.	390.	395.	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.
	s	0.44471	0.44931	0.45388	0.45841	0.46291	0.46738	0.47182	0.47622	0.48060	0.48494	0.48925	0.49353	0.49778	0.50201	0.50620	0.51036
	v	0.160	0.165	0.170	0.174	0.179	0.183	0.187	0.192	0.196	0.200	0.203	0.207	0.211	0.214	0.218	0.221
	d	6.2472	6.0589	5.8678	5.7321	5.5887	5.4561	5.3334	5.2192	5.1121	5.0117	4.9176	4.8283	4.7442	4.6649	4.5891	4.5172

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																	
500	T	754.015	762.348	770.672	778.995	787.304	795.609	803.904	812.188	820.459	828.719	836.967	845.196	853.414	861.614		
	h	450.	455.	460.	465.	470.	475.	480.	485.	490.	495.	500.	505.	510.	515.		
	s	0.51449	0.51860	0.52268	0.52673	0.53075	0.53475	0.53872	0.54266	0.54658	0.55047	0.55434	0.55819	0.56201	0.56580		
	v	0.225	0.228	0.231	0.235	0.238	0.241	0.244	0.247	0.250	0.253	0.256	0.259	0.262	0.265		
	d	4.4486	4.3833	4.3206	4.2608	4.2032	4.1480	4.0949	4.0439	3.9947	3.9472	3.9017	3.8574	3.8146	3.7731		
600	T	56.637	69.049	81.257	93.278	105.126	116.811	128.351	139.750	151.013	162.151	173.170	184.076	194.869	205.562	216.148	226.641
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00393	0.00564	0.01499	0.02413	0.03308	0.04184	0.05043	0.05885	0.06711	0.07522	0.08320	0.09103	0.09873	0.10631	0.11376	0.12111
	v	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.7948	54.4007	54.0097	53.6223	53.2374	52.8554	52.4759	52.0985	51.7234	51.3499	50.9780	50.6077	50.2386	49.8708	49.5041	49.1382
600	T	237.038	247.340	257.556	267.685	277.730	287.687	297.566	307.367	317.086	326.728	336.292	345.785	355.197	364.539	373.803	382.995
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12834	0.13546	0.14248	0.14941	0.15623	0.16297	0.16961	0.17618	0.18265	0.18905	0.19537	0.20161	0.20779	0.21389	0.21992	0.22588
	v	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023	0.023
	d	48.7727	48.4077	48.0428	47.6780	47.3132	46.9482	46.5823	46.2158	45.8485	45.4799	45.1100	44.7385	44.3642	43.9891	43.6109	43.2300
600	T	392.118	401.157	410.129	419.024	427.847	436.592	445.259	453.849	462.359	470.781	479.129	487.384	495.537	503.607	511.573	519.429
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23179	0.23762	0.24340	0.24912	0.25479	0.26039	0.26594	0.27144	0.27689	0.28228	0.28764	0.29294	0.29820	0.30341	0.30858	0.31371
	v	0.023	0.024	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.027	0.028
	d	42.8460	42.4584	42.0645	41.6595	41.2486	40.8316	40.4078	39.9765	39.5369	39.0896	38.6298	38.1621	37.6810	37.1885	36.6832	36.1611
600	T	527.163	534.778	542.261	549.580	556.742	563.682	570.430	576.884	583.020	588.736	593.944	598.486	602.045	604.646	605.956	
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	Phase
	s	0.31879	0.32384	0.32885	0.33382	0.33876	0.34366	0.34853	0.35337	0.35818	0.36296	0.36773	0.37245	0.37716	0.38205	0.38656	
	v	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.033	0.034	0.035	0.036	0.038	0.040	0.043	Change
	d	35.6218	35.0652	34.4882	33.8882	33.2602	32.6032	31.9119	31.1827	30.4077	29.5791	28.6791	27.7037	26.5792	25.1675	23.4827	
600	T	607.364	608.566	610.786	613.966	618.059	622.883	628.319	634.241	640.557	647.182	654.072	661.176	668.453	675.867	683.413	691.055
	h	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.	400.	405.
	s	0.40532	0.40992	0.41468	0.41935	0.42401	0.42863	0.43323	0.43781	0.44237	0.44691	0.45141	0.45588	0.46033	0.46475	0.46914	0.47350
	v	0.069	0.077	0.085	0.092	0.098	0.104	0.110	0.115	0.120	0.125	0.129	0.134	0.138	0.142	0.146	0.150
	d	14.4735	12.9753	11.7981	10.8999	10.1839	9.6005	9.1123	8.6958	8.3337	8.0160	7.7348	7.4831	7.2559	7.0485	6.8597	6.6856
600	T	698.784	706.585	714.439	722.351	730.299	738.286	746.301	754.339	762.395	770.463	778.546	786.635	794.733	802.826	810.927	819.022
	h	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.	480.	485.
	s	0.47783	0.48213	0.48640	0.49064	0.49486	0.49905	0.50321	0.50734	0.51145	0.51552	0.51957	0.52360	0.52760	0.53157	0.53552	0.53944
	v	0.153	0.157	0.160	0.164	0.167	0.170	0.174	0.177	0.180	0.183	0.186	0.189	0.191	0.194	0.197	0.200
	d	6.5251	6.3759	6.2365	6.1070	5.9850	5.8705	5.7626	5.6605	5.5640	5.4720	5.3849	5.3017	5.2227	5.1467	5.0743	5.0048
600	T	827.116	835.204	843.288	851.366	859.431											
	h	490.	495.	500.	505.	510.											
	s	0.54334	0.54721	0.55106	0.55489	0.55869											
	v	0.203	0.205	0.208	0.210	0.213											
	d	4.9379	4.8739	4.8121	4.7529	4.6953											
700	T	56.061	68.484	80.704	92.738	104.599	116.299	127.849	139.255	150.535	161.683	172.711	183.629	194.433	205.135	215.734	226.238
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00460	0.00498	0.01434	0.02349	0.03244	0.04121	0.04981	0.05824	0.06651	0.07463	0.08260	0.09044	0.09815	0.10573	0.11319	0.12054
	v	0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.8431	54.4501	54.0607	53.6742	53.2909	52.9103	52.5323	52.1564	51.7826	51.4110	51.0410	50.6725	50.3056	49.9396	49.5748	49.2112

T in F. P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
700	T	236.646	246.963	257.190	267.331	277.388	287.360	297.253	307.065	316.801	326.458	336.041	345.548	354.978	364.342	373.627	382.836
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12777	0.13490	0.14193	0.14885	0.15568	0.16242	0.16907	0.17563	0.18211	0.18851	0.19484	0.20108	0.20726	0.21336	0.21939	0.22536
	v	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023
	d	48.8479	48.4851	48.1228	47.7609	47.3989	47.0362	46.6739	46.3110	45.9468	45.5817	45.2158	44.8483	44.4789	44.1082	43.7349	43.3589
700	T	391.978	401.048	410.044	418.967	427.820	436.598	445.298	453.927	462.474	470.951	479.335	487.643	495.868	504.006	512.046	519.991
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23126	0.23710	0.24288	0.24860	0.25426	0.25987	0.26542	0.27092	0.27637	0.28176	0.28711	0.29241	0.29767	0.30288	0.30805	0.31317
	v	0.023	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027	0.027
	d	42.9805	42.5985	42.2124	41.8152	41.4136	41.0065	40.5931	40.1724	39.7450	39.3104	38.8659	38.4130	37.9503	37.4772	36.9914	36.4939
700	T	527.833	535.567	543.176	550.654	558.	565.187	572.190	579.000	585.589	591.905	597.909	603.490	608.628	613.193	617.108	620.366
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.31825	0.32330	0.32831	0.33326	0.33820	0.34310	0.34796	0.35279	0.35759	0.36236	0.36711	0.37181	0.37650	0.38117	0.38582	0.39047
	v	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.033	0.034	0.035	0.036	0.037	0.039	0.040
	d	35.9819	35.4546	34.9079	34.3480	33.7609	33.1536	32.5187	31.8560	31.1625	30.4321	29.6565	28.8370	27.9591	27.0047	25.9412	24.7113
700	T	623.112	625.613	628.090	630.677	633.455	636.519	639.939	643.786	648.092	652.869	658.087	663.699	669.661	675.917	682.424	689.143
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.39508	0.39970	0.40430	0.40889	0.41347	0.41804	0.42259	0.42713	0.43165	0.43616	0.44064	0.44510	0.44954	0.45396	0.45835	0.46271
	v	0.043	0.046	0.050	0.055	0.061	0.066	0.072	0.077	0.083	0.088	0.092	0.097	0.101	0.105	0.109	0.113
	d	23.2656	21.5985	19.8083	18.0489	16.4439	15.0573	13.8885	12.9107	12.0955	11.4088	10.8259	10.3233	9.8862	9.5010	9.1586	8.8508
700	T	696.056	703.123	710.321	717.633	725.042	732.541	740.108	747.733	755.418	763.143	770.908	778.702	786.529	794.372	802.237	810.118
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.46705	0.47137	0.47565	0.47992	0.48415	0.48836	0.49254	0.49669	0.50082	0.50492	0.50900	0.51305	0.51707	0.52107	0.52505	0.52900
	v	0.117	0.120	0.124	0.127	0.130	0.133	0.136	0.139	0.142	0.145	0.148	0.151	0.153	0.156	0.159	0.161
	d	8.5741	8.3215	8.0910	7.8784	7.6826	7.5015	7.3327	7.1745	7.0269	6.8885	6.7574	6.6338	6.5171	6.4063	6.3009	6.2009
700	T	818.010	825.915	833.822	841.731	849.645	857.561										
	h	480.	485.	490.	495.	500.	505.										
	s	0.53292	0.53682	0.54070	0.54455	0.54838	0.55219										
	v	0.164	0.166	0.169	0.171	0.174	0.176										
	d	6.1054	6.0144	5.9274	5.8435	5.7632	5.6864										
800	T	55.476	67.914	80.151	92.194	104.070	115.782	127.344	138.765	150.048	161.213	172.252	183.178	193.994	204.707	215.319	225.832
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00527	0.00432	0.01369	0.02284	0.03181	0.04059	0.04919	0.05763	0.06590	0.07403	0.08201	0.08986	0.09757	0.10516	0.11262	0.11997
	v	0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.8913	54.4995	54.1112	53.7262	53.3440	52.9648	52.5880	52.2138	51.8417	51.4716	51.1032	50.7366	50.3716	50.0076	49.6446	49.2829
800	T	236.252	246.578	256.819	266.971	277.041	287.026	296.933	306.757	316.509	326.179	335.779	345.302	354.752	364.127	373.434	382.671
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12721	0.13434	0.14137	0.14830	0.15514	0.16188	0.16853	0.17509	0.18158	0.18798	0.19430	0.20055	0.20673	0.21283	0.21886	0.22483
	v	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023
	d	48.9219	48.5617	48.2017	47.8426	47.4829	47.1233	46.7641	46.4038	46.0436	45.6817	45.3194	44.9558	44.5908	44.2237	43.8560	43.4851
800	T	391.830	400.921	409.943	418.892	427.773	436.577	445.312	453.970	462.557	471.073	479.510	487.871	496.150	504.341	512.448	520.468
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23074	0.23658	0.24236	0.24808	0.25374	0.25935	0.26490	0.27040	0.27585	0.28124	0.28659	0.29189	0.29714	0.30235	0.30752	0.31264
	v	0.023	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.026	0.027	0.027
	d	43.1116	42.7357	42.3553	41.9660	41.5724	41.1733	40.7691	40.3587	39.9419	39.5189	39.0884	38.6502	38.2034	37.7459	37.2780	36.8005

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
800	T	528.393	536.223	543.938	551.553	559.049	566.403	573.631	580.684	587.561	594.266	600.715	606.918	612.821	618.382	623.555	628.312
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.31772	0.32276	0.32776	0.33273	0.33765	0.34254	0.34740	0.35222	0.35701	0.36177	0.36649	0.37120	0.37587	0.38053	0.38515	0.38976
	v	0.028	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.033	0.034	0.035	0.036	0.037	0.038
	d	36.3097	35.8075	35.2899	34.7567	34.2074	33.6379	33.0503	32.4378	31.7986	31.1390	30.4476	29.7164	28.9530	28.1472	27.2916	26.3740
800	T	632.664	636.686	640.501	644.236	648.004	651.853	655.837	660.009	664.387	669.014	673.892	679.046	684.467	690.145	696.075	702.220
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.39434	0.39892	0.40346	0.40800	0.41253	0.41703	0.42152	0.42599	0.43045	0.43489	0.43931	0.44371	0.44809	0.45245	0.45679	0.46110
	v	0.039	0.041	0.043	0.046	0.049	0.053	0.057	0.061	0.065	0.069	0.073	0.078	0.081	0.085	0.089	0.092
	d	25.3739	24.2674	23.0460	21.7139	20.3210	18.9361	17.6198	16.4210	15.3535	14.4212	13.6100	12.9031	12.2859	11.7430	11.2633	10.8351
800	T	708.582	715.123	721.825	726.678	735.655	742.746	749.934	757.207	764.555	771.967	779.439	786.956	794.522	802.121	809.755	817.412
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.46540	0.46966	0.47391	0.47813	0.48232	0.48649	0.49064	0.49476	0.49886	0.50293	0.50698	0.51100	0.51500	0.51897	0.52292	0.52685
	v	0.096	0.099	0.102	0.105	0.108	0.111	0.114	0.117	0.119	0.122	0.125	0.127	0.130	0.132	0.135	0.137
	d	10.4521	10.1055	9.7909	9.5045	9.2413	8.9988	8.7745	8.5655	8.3717	8.1902	8.0198	7.8599	7.7091	7.5666	7.4316	7.3035
800	T	825.098	832.797	840.519	848.249	855.996											
	h	480.	485.	490.	495.	500.											
	s	0.53075	0.53463	0.53849	0.54233	0.54614											
	v	0.139	0.142	0.144	0.146	0.148											
	d	7.1824	7.0664	6.9563	6.8506	6.7500											
900	T	54.893	67.345	79.594	91.654	103.540	115.264	126.837	138.265	149.566	160.737	171.789	182.728	193.552	204.276	214.897	225.423
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00595	0.00365	0.01303	0.02220	0.03118	0.03996	0.04857	0.05701	0.06530	0.07343	0.08142	0.08927	0.09699	0.10458	0.11205	0.11940
	v	0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.9393	54.5486	54.1613	53.7777	53.3967	53.0188	52.6435	52.2708	51.9002	51.5319	51.1650	50.8001	50.4369	50.0750	49.7142	49.3545
900	T	235.854	246.192	256.442	266.609	276.688	286.690	296.607	306.447	316.208	325.896	335.509	345.051	354.516	363.910	373.233	382.484
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12665	0.13378	0.14082	0.14775	0.15459	0.16133	0.16799	0.17456	0.18104	0.18745	0.19377	0.20002	0.20620	0.21230	0.21834	0.22431
	v	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023	0.023
	d	48.9954	48.6375	48.2802	47.9230	47.5662	47.2095	46.8529	46.4959	46.1383	45.7799	45.4214	45.0615	44.7008	44.3381	43.9735	43.6075
900	T	391.668	400.782	409.825	418.797	427.703	436.541	445.304	453.998	462.618	471.170	479.644	488.049	496.378	504.623	512.796	520.873
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.23022	0.23606	0.24184	0.24756	0.25322	0.25883	0.26438	0.26988	0.27533	0.28072	0.28607	0.29137	0.29662	0.30183	0.30699	0.31211
	v	0.023	0.023	0.024	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.027	0.027
	d	43.2391	42.8688	42.4947	42.1115	41.7257	41.3348	40.9388	40.5377	40.1311	39.7185	39.2991	38.8732	38.4398	37.9967	37.5466	37.0847
900	T	528.877	536.789	544.602	552.313	559.935	567.425	574.807	582.059	589.167	596.102	602.883	609.479	615.855	621.997	627.878	633.485
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.31719	0.32223	0.32723	0.33219	0.33711	0.34200	0.34685	0.35166	0.35645	0.36120	0.36591	0.37061	0.37527	0.37991	0.38452	0.38910
	v	0.027	0.028	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.032	0.032	0.033	0.034	0.034	0.035	0.036
	d	36.6147	36.1333	35.6386	35.1305	34.6108	34.0726	33.5195	32.9487	32.3577	31.7426	31.1109	30.4485	29.7618	29.0466	28.3005	27.5211
900	T	638.804	643.850	648.669	653.328	657.898	662.457	667.042	671.705	676.468	681.354	686.386	691.575	696.936	702.468	708.179	714.068
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.39366	0.39821	0.40273	0.40723	0.41171	0.41618	0.42062	0.42505	0.42946	0.43385	0.43823	0.44258	0.44691	0.45123	0.45552	0.45979
	v	0.037	0.039	0.040	0.042	0.044	0.046	0.048	0.051	0.054	0.058	0.061	0.064	0.068	0.071	0.074	0.077
	d	26.7024	25.8378	24.9178	23.9357	22.8865	21.7627	20.6444	19.5111	18.4132	17.3801	16.4305	15.5702	14.7976	14.1070	13.4906	12.9386

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																
900	T	720.116	726.336	732.697	739.208	745.839	752.600	759.466	766.428	773.475	780.608	787.805	795.071	802.383	809.751	817.160	824.609
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.46404	0.46826	0.47247	0.47665	0.48081	0.48495	0.48906	0.49315	0.49721	0.50126	0.50528	0.50927	0.51325	0.51720	0.52112	0.52503
	v	0.080	0.083	0.086	0.089	0.092	0.095	0.097	0.100	0.102	0.105	0.107	0.109	0.112	0.114	0.116	0.118
	d	12.4433	11.9960	11.5899	11.2211	10.8830	10.5736	10.2883	10.0235	9.7777	9.5493	9.3355	9.1355	8.9469	8.7697	8.6025	8.4441
900	T	832.087	839.599	847.135	854.694	862.272											
	h	480.	485.	490.	495.	500.											
	s	0.52891	0.53277	0.53661	0.54042	0.54422											
	v	0.121	0.123	0.125	0.127	0.129											
	d	8.2940	8.1518	8.0163	7.8874	7.7642											
1000	T	54.307	66.773	79.037	91.110	103.006	114.744	126.325	137.769	149.079	160.261	171.323	182.272	193.108	203.844	214.476	225.012
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70.	75.
	s	-0.00662	0.00299	0.01238	0.02156	0.03054	0.03934	0.04795	0.05640	0.06470	0.07283	0.08083	0.08868	0.09641	0.10400	0.11148	0.11884
	v	0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020	0.020
	d	54.9867	54.5973	54.2112	53.8285	53.4492	53.0726	52.6987	52.3275	51.9581	51.5914	51.2264	50.8631	50.5016	50.1414	49.7824	49.4247
1000	T	235.452	245.803	256.064	266.242	276.334	286.343	296.279	306.130	315.906	325.607	335.235	344.792	354.272	363.681	373.023	382.292
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12609	0.13323	0.14026	0.14720	0.15404	0.16079	0.16745	0.17402	0.18051	0.18691	0.19324	0.19949	0.20567	0.21178	0.21782	0.22379
	v	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023
	d	49.0679	48.7122	48.3573	48.0023	47.6480	47.2938	46.9404	46.5860	46.2315	45.8767	45.5214	45.1653	44.8078	44.4489	44.0892	43.7277
1000	T	391.498	400.629	409.694	418.690	427.622	436.483	445.273	453.994	462.652	471.236	479.750	488.196	496.569	504.863	513.080	521.227
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.22970	0.23554	0.24132	0.24704	0.25271	0.25831	0.26387	0.26936	0.27481	0.28021	0.28555	0.29085	0.29610	0.30131	0.30647	0.31159
	v	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.026	0.027
	d	43.3642	42.9988	42.6299	42.2534	41.8744	41.4904	41.1020	40.7099	40.3120	39.9087	39.4997	39.0855	38.6639	38.2341	37.7967	37.3528
1000	T	529.288	537.264	545.168	552.968	560.677	568.286	575.805	583.200	590.473	597.612	604.632	611.496	618.196	624.719	631.056	637.194
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.31667	0.32170	0.32670	0.33165	0.33657	0.34146	0.34630	0.35111	0.35589	0.36064	0.36535	0.37003	0.37469	0.37931	0.38391	0.38848
	v	0.027	0.027	0.028	0.028	0.029	0.029	0.029	0.030	0.030	0.031	0.032	0.032	0.033	0.034	0.034	0.035
	d	36.8981	36.4353	35.9613	35.4758	34.9783	34.4677	33.9461	33.4064	32.8515	32.2776	31.6888	31.0801	30.4504	29.7995	29.1272	28.4314
1000	T	643.119	648.842	654.365	659.729	664.963	670.114	675.240	680.363	685.527	690.746	696.042	701.430	706.924	712.528	718.255	724.105
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.39303	0.39755	0.40204	0.40652	0.41098	0.41542	0.41983	0.42423	0.42860	0.43296	0.43730	0.44161	0.44591	0.45018	0.45444	0.45867
	v	0.036	0.037	0.038	0.039	0.041	0.042	0.044	0.046	0.048	0.050	0.053	0.055	0.058	0.061	0.064	0.066
	d	27.7117	26.9672	26.1967	25.3936	24.5565	23.6800	22.7679	21.8245	20.8655	19.9085	18.9734	18.0787	17.2364	16.4580	15.7392	15.0843
1000	T	730.072	736.164	742.376	748.704	755.145	761.694	768.334	775.075	781.903	788.808	795.793	802.838	809.948	817.107	824.324	831.582
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.46289	0.46708	0.47125	0.47540	0.47952	0.48363	0.48771	0.49177	0.49581	0.49983	0.50382	0.50779	0.51174	0.51567	0.51957	0.52346
	v	0.069	0.072	0.074	0.077	0.079	0.082	0.084	0.087	0.089	0.091	0.094	0.096	0.098	0.100	0.102	0.104
	d	14.4859	13.9422	13.4473	12.9944	12.5803	12.2007	11.8496	11.5262	11.2270	10.9480	10.6885	10.4451	10.2174	10.0028	9.8016	9.6108
1000	T	838.881	846.214	853.580	860.975												
	h	480.	485.	490.	495.												
	s	0.52732	0.53116	0.53498	0.53877												
	v	0.106	0.108	0.110	0.112												
	d	9.4312	9.2602	9.0979	8.9439												

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-7, Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Pressure and Enthalpy

Press.																	
1200	T	53.129	65.625	77.916	90.013	101.938	113.698	125.305	136.770	148.100	159.305	170.384	181.352	192.213	202.967	213.619	224.177
	h	0.	5.	10.	15.	20.	25.	30.	35.	40.	45.	50.	55.	60.	65.	70	75.
	s	-0.00796	0.00167	0.01108	0.02027	0.02927	0.03809	0.04672	0.05518	0.06349	0.07164	0.07964	0.08751	0.09525	0.10285	0.11034	0.11771
	v	0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.020	0.020	0.020	0.020	0.020
	d	55.0813	54.6939	54.3102	53.9301	53.5529	53.1789	52.8077	52.4392	52.0729	51.7091	51.3473	50.9871	50.6289	50.2726	49.9173	49.5635
1200	T	234.638	245.013	255.296	265.495	275.610	285.647	295.601	305.478	315.280	325.009	334.660	344.247	353.759	363.200	372.574	381.880
	h	80.	85.	90.	95.	100.	105.	110.	115.	120.	125.	130.	135.	140.	145.	150.	155.
	s	0.12496	0.13211	0.13916	0.14610	0.15295	0.15970	0.16637	0.17294	0.17944	0.18585	0.19218	0.19844	0.20462	0.21073	0.21678	0.22275
	v	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.023	0.023
	d	49.2112	48.8593	48.5083	48.1584	47.8090	47.4602	47.1112	46.7626	46.4140	46.0653	45.7162	45.3668	45.0165	44.6651	44.3132	43.9601
1200	T	391.117	400.290	409.393	418.433	427.405	436.313	445.156	453.933	462.646	471.292	479.874	488.386	496.836	505.217	513.521	521.764
	h	160.	165.	170.	175.	180.	185.	190.	195.	200.	205.	210.	215.	220.	225.	230.	235.
	s	0.22866	0.23450	0.24029	0.24601	0.25168	0.25729	0.26284	0.26834	0.27378	0.27918	0.28453	0.28982	0.29507	0.30028	0.30544	0.31056
	v	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.026
	d	43.6053	43.2493	42.8902	42.5256	42.1582	41.7869	41.4127	41.0347	40.6531	40.2672	39.8764	39.4805	39.0803	38.6738	38.2600	37.8406
1200	T	529.931	538.035	546.054	553.999	561.872	569.667	577.366	584.983	592.505	599.946	607.271	614.499	621.617	628.622	635.507	642.267
	h	240.	245.	250.	255.	260.	265.	270.	275.	280.	285.	290.	295.	300.	305.	310.	315.
	s	0.31563	0.32066	0.32565	0.33060	0.33552	0.34040	0.34523	0.35004	0.35480	0.35954	0.36424	0.36891	0.37355	0.37816	0.38274	0.38729
	v	0.027	0.027	0.027	0.028	0.028	0.028	0.029	0.029	0.030	0.030	0.031	0.031	0.032	0.032	0.033	0.033
	d	37.4152	36.9828	36.5412	36.0916	35.6342	35.1667	34.6906	34.2016	33.7037	33.1945	32.6704	32.1353	31.5867	31.0247	30.4497	29.8607
1200	T	648.899	655.403	661.779	668.031	674.172	680.212	686.171	692.071	697.932	703.776	709.622	715.480	721.371	727.303	733.276	739.311
	h	320.	325.	330.	335.	340.	345.	350.	355.	360.	365.	370.	375.	380.	385.	390.	395.
	s	0.39182	0.39631	0.40078	0.40523	0.40965	0.41405	0.41843	0.42278	0.42711	0.43141	0.43570	0.43997	0.44421	0.44844	0.45264	0.45682
	v	0.034	0.035	0.036	0.037	0.037	0.038	0.039	0.040	0.042	0.043	0.044	0.046	0.047	0.049	0.051	0.053
	d	29.2588	28.6444	28.0180	27.3801	26.7323	26.0733	25.4034	24.7212	24.0265	23.3197	22.5999	21.8731	21.1422	20.4178	19.7043	19.0111
1200	T	745.395	751.547	757.764	764.049	770.396	776.816	783.306	789.858	796.477	803.150	809.887	816.680	823.528	830.428	837.376	844.367
	h	400.	405.	410.	415.	420.	425.	430.	435.	440.	445.	450.	455.	460.	465.	470.	475.
	s	0.46098	0.46512	0.46924	0.47333	0.47741	0.48146	0.48549	0.48951	0.49350	0.49747	0.50142	0.50534	0.50925	0.51314	0.51700	0.52085
	v	0.055	0.056	0.058	0.061	0.063	0.065	0.067	0.069	0.070	0.072	0.074	0.076	0.078	0.080	0.082	0.083
	d	18.3425	17.7037	17.0983	16.5288	15.9934	15.4930	15.0269	14.5913	14.1861	13.8060	13.4521	13.1207	12.8106	12.5193	12.2454	11.9875
1200	T	851.401	858.469														
	h	480.	485.														
	s	0.52467	0.52847														
	v	0.085	0.087														
	d	11.7441	11.5132														

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-8, Saturation Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Quality

Temp																
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
60.	P	0.329	0.329	0.328	0.328	0.325	0.324	0.322	0.319	0.309	0.302	0.290	0.275	0.256	0.179	0.112	0.047
	h	-0.035	54.138	90.254	126.371	162.494	166.106	169.715	173.333	176.948	177.857	178.765	179.312	179.682	180.256	180.480	180.768
	s	0.00002	0.10427	0.17380	0.24334	0.31304	0.32006	0.32712	0.33431	0.34194	0.34414	0.34678	0.34898	0.35119	0.36000	0.37048	0.38957
	v	0.018	55.090	91.932	128.934	167.285	171.549	176.164	181.916	191.664	196.788	206.208	218.121	234.514	336.736	538.596	1281.199
	d	54.5014	0.0182	0.0109	0.0078	0.0060	0.0058	0.0057	0.0055	0.0052	0.0051	0.0048	0.0046	0.0043	0.0030	0.0019	0.0008
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
70.	P	0.446	0.446	0.445	0.444	0.440	0.439	0.436	0.432	0.418	0.410	0.393	0.373	0.349	0.250	0.167	0.079
	h	4.017	57.764	93.599	129.435	165.277	168.860	172.443	176.026	179.619	180.518	181.421	181.968	182.334	182.909	183.139	183.418
	s	0.00774	0.10922	0.17690	0.24460	0.31246	0.31929	0.32617	0.33316	0.34062	0.34276	0.34535	0.34749	0.34966	0.35790	0.36698	0.38344
	v	0.018	41.386	69.083	96.910	125.750	128.942	132.427	136.659	144.024	147.790	154.796	163.593	175.570	245.883	368.638	776.567
	d	54.1757	0.0242	0.0145	0.0103	0.0080	0.0078	0.0076	0.0073	0.0069	0.0068	0.0065	0.0061	0.0057	0.0041	0.0027	0.0013
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
80.	P	0.597	0.596	0.595	0.594	0.589	0.587	0.584	0.578	0.560	0.549	0.527	0.501	0.469	0.344	0.244	0.129
	h	8.124	61.444	96.992	132.546	168.098	171.655	175.214	178.774	182.339	183.225	184.124	184.662	185.029	185.612	185.843	186.123
	s	0.01542	0.11423	0.18013	0.24605	0.31211	0.31877	0.32548	0.33230	0.33958	0.34166	0.34419	0.34627	0.34837	0.35605	0.36387	0.37797
	v	0.019	31.500	52.570	73.765	95.655	98.113	100.799	104.063	109.636	112.412	117.684	124.148	132.944	181.571	256.860	485.155
	d	53.8476	0.0317	0.0190	0.0136	0.0105	0.0102	0.0099	0.0096	0.0091	0.0089	0.0085	0.0081	0.0075	0.0055	0.0039	0.0021
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
90.	P	0.788	0.787	0.786	0.785	0.778	0.775	0.771	0.763	0.740	0.725	0.697	0.664	0.623	0.470	0.350	0.205
	h	12.282	65.175	100.439	135.706	170.974	174.504	178.029	181.562	185.095	185.984	186.874	187.417	187.778	188.365	188.598	188.876
	s	0.02305	0.11929	0.18347	0.24767	0.31202	0.31851	0.32503	0.33169	0.33877	0.34082	0.34329	0.34532	0.34734	0.35444	0.36116	0.37313
	v	0.019	24.290	40.520	56.846	73.717	75.613	77.647	80.159	84.399	86.583	90.529	95.418	101.866	135.578	182.190	311.931
	d	53.5175	0.0412	0.0247	0.0176	0.0136	0.0132	0.0129	0.0125	0.0118	0.0115	0.0110	0.0105	0.0098	0.0074	0.0055	0.0032
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
100.	P	1.028	1.027	1.026	1.024	1.015	1.012	1.007	0.996	0.966	0.947	0.912	0.869	0.818	0.634	0.494	0.315
	h	16.494	68.955	103.931	138.912	173.892	177.394	180.892	184.390	187.900	188.780	189.669	190.200	190.568	191.160	191.398	191.676
	s	0.03064	0.12439	0.18691	0.24945	0.31213	0.31846	0.32482	0.33130	0.33822	0.34021	0.34262	0.34459	0.34654	0.35306	0.35880	0.36889
	v	0.019	18.937	31.579	44.301	57.436	58.914	60.499	62.436	65.725	67.388	70.420	74.038	78.851	102.265	131.414	206.236
	d	53.1849	0.0528	0.0317	0.0226	0.0174	0.0170	0.0165	0.0160	0.0152	0.0148	0.0142	0.0135	0.0127	0.0098	0.0076	0.0048
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
110.	P	1.327	1.326	1.324	1.322	1.310	1.306	1.300	1.287	1.249	1.225	1.181	1.128	1.067	0.846	0.686	0.473
	h	20.754	72.782	107.473	142.159	176.855	180.323	183.795	187.272	190.752	191.621	192.507	193.037	193.410	193.998	194.238	194.511
	s	0.03819	0.12953	0.19044	0.25137	0.31246	0.31862	0.32482	0.33114	0.33788	0.33981	0.34215	0.34405	0.34591	0.35190	0.35679	0.36522
	v	0.019	14.915	24.882	34.880	45.240	46.382	47.637	49.163	51.704	52.953	55.259	57.995	61.525	77.922	96.301	139.974
	d	52.8505	0.0670	0.0402	0.0287	0.0221	0.0216	0.0210	0.0203	0.0193	0.0189	0.0181	0.0172	0.0163	0.0128	0.0104	0.0071
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
120.	P	1.695	1.693	1.692	1.688	1.674	1.669	1.660	1.644	1.597	1.567	1.512	1.448	1.374	1.120	0.937	0.689
	h	25.065	76.659	111.056	145.452	179.861	183.298	186.743	190.189	193.641	194.509	195.384	195.917	196.281	196.882	197.120	197.392
	s	0.04569	0.13471	0.19406	0.25344	0.31298	0.31897	0.32502	0.33118	0.33775	0.33964	0.34192	0.34376	0.34550	0.35090	0.35512	0.36212
	v	0.019	11.874	19.794	27.748	35.994	36.895	37.897	39.097	41.092	42.080	43.853	45.929	48.517	59.820	71.674	97.534
	d	52.5135	0.0842	0.0505	0.0360	0.0278	0.0271	0.0264	0.0256	0.0243	0.0238	0.0228	0.0218	0.0206	0.0167	0.0140	0.0103
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
130.	P	2.143	2.141	2.139	2.135	2.118	2.111	2.101	2.080	2.023	1.987	1.920	1.844	1.756	1.463	1.262	0.981
	h	29.424	80.579	114.684	148.791	182.905	186.316	189.734	193.147	196.573	197.434	198.307	198.843	199.205	199.807	200.040	200.314
	s	0.05314	0.13990	0.19776	0.25564	0.31367	0.31951	0.32542	0.33141	0.33782	0.33966	0.34186	0.34363	0.34528	0.35019	0.35373	0.35954
	v	0.019	9.537	15.898	22.292	28.900	29.626	30.432	31.378	32.950	33.718	35.089	36.672	38.589	46.539	54.056	69.653
	d	52.1747	0.1049	0.0629	0.0449	0.0346	0.0338	0.0329	0.0319	0.0303	0.0297	0.0285	0.0273	0.0259	0.0215	0.0185	0.0144

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-8, Saturation Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Quality

Temp																
140.	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
	P	2.685	2.683	2.680	2.675	2.653	2.646	2.633	2.608	2.537	2.493	2.413	2.323	2.220	1.893	1.671	1.359
	h	33.830	84.544	118.357	152.168	185.989	189.374	192.758	196.147	199.545	200.401	201.269	201.800	202.166	202.761	202.997	203.272
	s	0.06054	0.14513	0.20153	0.25795	0.31452	0.32023	0.32597	0.33183	0.33808	0.33987	0.34201	0.34370	0.34527	0.34965	0.35269	0.35753
	v	0.019	7.729	12.885	18.059	23.410	24.003	24.645	25.417	26.673	27.282	28.343	29.548	30.990	36.509	41.431	51.057
	d	51.8334	0.1294	0.0776	0.0554	0.0427	0.0417	0.0406	0.0393	0.0375	0.0367	0.0353	0.0338	0.0323	0.0274	0.0241	0.0196
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
150.	P	3.334	3.332	3.329	3.323	3.296	3.287	3.272	3.242	3.158	3.107	3.012	2.907	2.789	2.422	2.185	1.847
	h	38.283	88.553	122.068	155.588	189.112	192.467	195.821	199.180	202.551	203.405	204.264	204.795	205.157	205.763	205.998	206.265
	s	0.06790	0.15037	0.20536	0.26038	0.31553	0.32109	0.32669	0.33239	0.33848	0.34022	0.34228	0.34391	0.34538	0.34936	0.35192	0.35592
	v	0.019	6.318	10.525	14.759	19.121	19.603	20.121	20.740	21.738	22.221	23.036	23.959	25.031	28.970	32.174	38.140
	d	51.4900	0.1583	0.0950	0.0678	0.0523	0.0510	0.0497	0.0482	0.0460	0.0450	0.0434	0.0417	0.0400	0.0345	0.0311	0.0262
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
160.	P	4.106	4.103	4.100	4.093	4.064	4.054	4.036	4.003	3.911	3.854	3.752	3.628	3.498	3.076	2.819	2.459
	h	42.781	92.605	125.822	159.046	192.273	195.593	198.920	202.249	205.596	206.439	207.295	207.821	208.187	208.788	209.021	209.290
	s	0.07522	0.15563	0.20925	0.26290	0.31667	0.32208	0.32754	0.33308	0.33898	0.34064	0.34259	0.34415	0.34551	0.34919	0.35140	0.35472
	v	0.020	5.205	8.668	12.152	15.732	16.117	16.538	17.030	17.806	18.162	18.763	19.470	20.249	23.129	25.282	29.055
	d	51.1445	0.1921	0.1154	0.0823	0.0636	0.0620	0.0605	0.0587	0.0562	0.0551	0.0533	0.0514	0.0494	0.0432	0.0396	0.0344
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
170.	P	5.018	5.015	5.011	5.004	4.974	4.964	4.946	4.913	4.819	4.752	4.643	4.519	4.341	3.884	3.601	3.195
	h	47.326	96.699	129.616	162.538	195.465	198.757	202.051	205.358	208.664	209.503	210.355	210.874	211.244	211.847	212.084	212.352
	s	0.08249	0.16091	0.21320	0.26551	0.31793	0.32320	0.32850	0.33390	0.33955	0.34117	0.34302	0.34441	0.34584	0.34913	0.35110	0.35404
	v	0.020	4.319	7.190	10.075	13.026	13.342	13.678	14.073	14.644	14.928	15.369	15.840	16.534	18.568	20.073	22.674
	d	50.7961	0.2315	0.1391	0.0993	0.0768	0.0750	0.0731	0.0711	0.0683	0.0670	0.0651	0.0631	0.0605	0.0539	0.0498	0.0441
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
180.	P	6.089	6.086	6.084	6.079	6.062	6.056	6.046	6.027	5.973	5.938	5.874	5.792	5.691	4.993	4.579	4.101
	h	51.915	100.834	133.449	166.060	198.680	201.949	205.210	208.482	211.758	212.579	213.414	213.914	214.274	214.914	215.167	215.449
	s	0.08971	0.16619	0.21719	0.26818	0.31923	0.32436	0.32949	0.33467	0.33998	0.34139	0.34292	0.34395	0.34510	0.34865	0.35086	0.35361
	v	0.020	3.607	6.003	8.397	10.822	11.077	11.334	11.616	11.968	12.099	12.300	12.509	12.332	14.634	15.992	17.907
	d	50.4459	0.2772	0.1666	0.1191	0.0924	0.0903	0.0882	0.0861	0.0836	0.0827	0.0813	0.0799	0.0811	0.0683	0.0625	0.0558
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
190.	P	7.329	7.324	7.319	7.311	7.273	7.259	7.237	7.195	7.080	7.010	6.885	6.747	6.596	6.126	5.810	5.306
	h	56.549	105.010	137.315	169.626	201.954	205.184	208.422	211.663	214.920	215.739	216.578	217.090	217.447	218.028	218.267	218.545
	s	0.09689	0.17149	0.22123	0.27099	0.32086	0.32587	0.33091	0.33602	0.34137	0.34284	0.34450	0.34571	0.34673	0.34916	0.35063	0.35295
	v	0.020	3.038	5.050	7.070	9.140	9.357	9.591	9.854	10.227	10.382	10.632	10.884	11.163	12.071	12.758	14.006
	d	50.0928	0.3292	0.1980	0.1414	0.1094	0.1069	0.1043	0.1015	0.0978	0.0963	0.0941	0.0919	0.0896	0.0828	0.0784	0.0714
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
200.	P	8.765	8.759	8.754	8.742	8.693	8.676	8.648	8.594	8.446	8.358	8.205	8.040	7.862	7.344	7.018	6.528
	h	61.225	109.223	141.227	173.228	205.247	208.450	211.653	214.869	218.097	218.911	219.745	220.266	220.623	221.206	221.437	221.706
	s	0.10403	0.17680	0.22532	0.27386	0.32251	0.32741	0.33233	0.33733	0.34258	0.34404	0.34568	0.34689	0.34789	0.35019	0.35148	0.35339
	v	0.020	2.571	4.277	5.986	7.737	7.925	8.121	8.350	8.675	8.811	9.027	9.249	9.483	10.196	10.693	11.526
	d	49.7374	0.3889	0.2338	0.1671	0.1292	0.1262	0.1231	0.1198	0.1153	0.1135	0.1108	0.1081	0.1055	0.0981	0.0935	0.0868
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
210.	P	10.418	10.411	10.404	10.390	10.330	10.309	10.274	10.209	10.032	9.930	9.751	9.564	9.368	8.829	8.507	8.043
	h	65.947	113.478	145.169	176.865	208.571	211.740	214.916	218.099	221.298	222.112	222.941	223.459	223.815	224.394	224.629	224.877
	s	0.11112	0.18211	0.22944	0.27680	0.32426	0.32903	0.33385	0.33873	0.34387	0.34529	0.34690	0.34807	0.34903	0.35112	0.35224	0.35377
	v	0.020	2.190	3.640	5.097	6.587	6.745	6.915	7.108	7.385	7.503	7.683	7.864	8.050	8.579	8.928	9.461
	d	49.3789	0.4566	0.2747	0.1962	0.1518	0.1483	0.1446	0.1407	0.1354	0.1333	0.1302	0.1272	0.1242	0.1166	0.1120	0.1057

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-8, Saturation Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Quality

Temp																	
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
220.	P	12.308	12.300	12.292	12.275	12.203	12.178	12.137	12.059	11.854	11.736	11.537	11.332	11.123	10.568	10.254	9.817
	h	70.711	117.772	149.148	180.528	211.918	215.061	218.210	221.360	224.543	225.344	226.171	226.676	227.031	227.610	227.831	228.070
	s	0.11817	0.18742	0.23360	0.27979	0.32609	0.33076	0.33546	0.34023	0.34526	0.34664	0.34821	0.34932	0.35022	0.35212	0.35307	0.35432
	v	0.020	1.877	3.116	4.361	5.635	5.772	5.919	6.084	6.324	6.419	6.569	6.710	6.854	7.247	7.485	7.834
	d	49.0182	0.5329	0.3209	0.2293	0.1775	0.1732	0.1689	0.1644	0.1581	0.1558	0.1522	0.1490	0.1459	0.1380	0.1336	0.1277
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
230.	P	14.459	14.450	14.440	14.420	14.335	14.305	14.257	14.167	13.930	13.798	13.578	13.357	13.138	12.577	12.273	11.862
	h	75.520	122.104	153.163	184.223	215.302	218.407	221.520	224.643	227.799	228.603	229.413	229.926	230.275	230.844	231.059	231.296
	s	0.12518	0.19274	0.23778	0.28285	0.32803	0.33257	0.33715	0.34181	0.34673	0.34809	0.34959	0.35066	0.35151	0.35322	0.35403	0.35507
	v	0.021	1.616	2.682	3.752	4.848	4.964	5.089	5.231	5.436	5.519	5.638	5.754	5.864	6.153	6.318	6.552
	d	48.6540	0.6188	0.3728	0.2666	0.2063	0.2014	0.1965	0.1912	0.1839	0.1812	0.1774	0.1738	0.1705	0.1625	0.1583	0.1526
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
240.	P	16.894	16.883	16.872	16.849	16.749	16.711	16.655	16.551	16.286	16.140	15.900	15.666	15.438	14.878	14.585	14.201
	h	80.372	126.471	157.205	187.948	218.699	221.787	224.869	227.963	231.084	231.874	232.687	233.186	233.543	234.102	234.313	234.539
	s	0.13215	0.19805	0.24199	0.28595	0.33002	0.33448	0.33895	0.34350	0.34828	0.34960	0.35106	0.35207	0.35288	0.35442	0.35513	0.35599
	v	0.021	1.399	2.318	3.243	4.188	4.293	4.401	4.524	4.696	4.763	4.863	4.952	5.041	5.253	5.369	5.526
	d	48.2869	0.7150	0.4314	0.3084	0.2388	0.2329	0.2272	0.2210	0.2129	0.2100	0.2056	0.2019	0.1984	0.1904	0.1862	0.1810
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
250.	P	19.633	19.621	19.608	19.581	19.465	19.425	19.361	19.243	18.946	18.786	18.529	18.283	18.049	17.494	17.215	16.856
	h	85.268	130.879	161.286	191.701	222.129	225.183	228.227	231.293	234.385	235.172	235.981	236.483	236.825	237.383	237.591	237.801
	s	0.13909	0.20337	0.24623	0.28911	0.33210	0.33645	0.34080	0.34525	0.34991	0.35119	0.35261	0.35358	0.35432	0.35574	0.35635	0.35707
	v	0.021	1.217	2.015	2.817	3.637	3.727	3.819	3.926	4.073	4.130	4.212	4.285	4.351	4.510	4.593	4.697
	d	47.9162	0.8219	0.4964	0.3550	0.2749	0.2683	0.2619	0.2547	0.2455	0.2421	0.2374	0.2334	0.2298	0.2217	0.2177	0.2129
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
260.	P	22.711	22.697	22.682	22.651	22.518	22.472	22.399	22.265	21.936	21.763	21.490	21.235	20.997	20.452	20.187	19.854
	h	90.206	135.321	165.396	195.480	225.583	228.592	231.619	234.647	237.714	238.495	239.288	239.789	240.135	240.684	240.868	241.083
	s	0.14598	0.20868	0.25048	0.29231	0.33425	0.33847	0.34274	0.34707	0.35163	0.35287	0.35422	0.35515	0.35586	0.35715	0.35766	0.35829
	v	0.021	1.063	1.757	2.456	3.172	3.247	3.330	3.422	3.549	3.596	3.662	3.720	3.773	3.892	3.946	4.022
	d	47.5427	0.9412	0.5690	0.4072	0.3153	0.3079	0.3003	0.2922	0.2818	0.2781	0.2731	0.2688	0.2650	0.2570	0.2534	0.2487
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
270.	P	26.150	26.135	26.117	26.082	25.928	25.876	25.794	25.644	25.283	25.097	24.810	24.548	24.309	23.778	23.528	23.220
	h	95.189	139.798	169.543	199.291	229.053	232.041	235.029	238.024	241.064	241.841	242.632	243.114	243.455	243.991	244.178	244.387
	s	0.15284	0.21398	0.25476	0.29555	0.33645	0.34059	0.34475	0.34897	0.35341	0.35462	0.35593	0.35680	0.35746	0.35863	0.35910	0.35964
	v	0.021	0.932	1.541	2.151	2.776	2.844	2.916	2.995	3.104	3.145	3.200	3.244	3.285	3.373	3.413	3.466
	d	47.1649	1.0730	0.6491	0.4648	0.3602	0.3516	0.3430	0.3339	0.3221	0.3180	0.3125	0.3083	0.3044	0.2965	0.2930	0.2885
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
280.	P	29.978	29.960	29.940	29.900	29.725	29.666	29.573	29.407	29.015	28.817	28.518	28.252	28.013	27.500	27.265	26.981
	h	100.216	144.313	173.712	203.121	232.552	235.496	238.453	241.427	244.428	245.195	245.978	246.461	246.794	247.324	247.509	247.701
	s	0.15966	0.21928	0.25904	0.29883	0.33873	0.34275	0.34680	0.35094	0.35525	0.35642	0.35769	0.35852	0.35914	0.36022	0.36064	0.36110
	v	0.021	0.821	1.354	1.891	2.441	2.499	2.561	2.632	2.725	2.759	2.804	2.840	2.872	2.938	2.968	3.004
	d	46.7833	1.2182	0.7383	0.5288	0.4097	0.4002	0.3904	0.3799	0.3670	0.3625	0.3567	0.3521	0.3482	0.3403	0.3369	0.3329
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
290.	P	34.223	34.203	34.180	34.134	33.936	33.870	33.766	33.582	33.160	32.952	32.644	32.375	32.139	31.646	31.426	31.165
	h	105.288	148.861	177.917	206.971	236.060	238.976	241.899	244.831	247.804	248.565	249.345	249.817	250.147	250.664	250.842	251.038
	s	0.16644	0.22458	0.26335	0.30213	0.34104	0.34497	0.34893	0.35294	0.35715	0.35829	0.35951	0.36030	0.36088	0.36187	0.36224	0.36267
	v	0.022	0.725	1.196	1.668	2.152	2.204	2.259	2.320	2.400	2.429	2.466	2.495	2.520	2.570	2.591	2.619
	d	46.3975	1.3786	0.8362	0.5997	0.4647	0.4537	0.4427	0.4311	0.4166	0.4117	0.4055	0.4008	0.3969	0.3891	0.3859	0.3819

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-8, Saturation Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Quality

Temp		q 0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
300.	P	38.914	38.891	38.865	38.813	38.590	38.516	38.402	38.200	37.749	37.532	37.217	36.948	36.717	36.245	36.040	35.801
	h	110.404	153.449	182.151	210.856	239.587	242.467	245.363	248.265	251.194	251.957	252.727	253.190	253.518	254.020	254.198	254.383
	s	0.17320	0.22987	0.26766	0.30547	0.34340	0.34723	0.35110	0.35502	0.35910	0.36022	0.36139	0.36214	0.36269	0.36360	0.36394	0.36431
	v	0.022	0.644	1.060	1.477	1.904	1.950	1.999	2.053	2.121	2.146	2.177	2.200	2.220	2.257	2.274	2.293
	d	46.0076	1.5531	0.9437	0.6771	0.5252	0.5129	0.5002	0.4871	0.4715	0.4659	0.4593	0.4546	0.4505	0.4430	0.4398	0.4361
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
310.	P	44.080	44.055	44.026	43.966	43.717	43.635	43.509	43.290	42.811	42.587	42.267	42.001	41.775	41.327	41.136	40.918
	h	115.565	158.072	186.408	214.758	243.135	245.977	248.832	251.697	254.609	255.358	256.106	256.576	256.888	257.385	257.563	257.736
	s	0.17992	0.23516	0.27198	0.30884	0.34581	0.34954	0.35331	0.35712	0.36112	0.36219	0.36330	0.36403	0.36454	0.36539	0.36571	0.36604
	v	0.022	0.574	0.941	1.312	1.691	1.731	1.774	1.821	1.881	1.902	1.927	1.946	1.961	1.990	2.003	2.016
	d	45.6132	1.7433	1.0622	0.7624	0.5915	0.5778	0.5638	0.5492	0.5316	0.5257	0.5191	0.5139	0.5100	0.5024	0.4993	0.4959
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
320.	P	49.754	49.725	49.692	49.626	49.347	49.256	49.119	48.882	48.378	48.149	47.828	47.565	47.347	46.923	46.746	46.546
	h	120.772	162.727	190.700	218.682	246.693	249.510	252.325	255.154	258.030	258.772	259.504	259.968	260.279	260.760	260.938	261.104
	s	0.18661	0.24043	0.27632	0.31223	0.34826	0.35191	0.35557	0.35929	0.36317	0.36421	0.36528	0.36597	0.36646	0.36724	0.36754	0.36784
	v	0.022	0.512	0.840	1.168	1.505	1.542	1.579	1.621	1.673	1.691	1.711	1.727	1.739	1.761	1.771	1.781
	d	45.2134	1.9523	1.1910	0.8558	0.6644	0.6486	0.6332	0.6170	0.5977	0.5913	0.5845	0.5791	0.5751	0.5679	0.5646	0.5615
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
330.	P	55.965	55.933	55.896	55.821	55.512	55.413	55.263	55.009	54.483	54.250	53.929	53.673	53.462	53.063	52.900	52.718
	h	126.027	167.419	195.015	222.619	250.263	253.040	255.819	258.619	261.455	262.185	262.922	263.367	263.675	264.155	264.313	264.482
	s	0.19327	0.24570	0.28066	0.31563	0.35074	0.35429	0.35786	0.36149	0.36526	0.36626	0.36730	0.36796	0.36842	0.36916	0.36942	0.36970
	v	0.022	0.459	0.751	1.043	1.344	1.376	1.409	1.446	1.492	1.507	1.524	1.536	1.546	1.564	1.571	1.579
	d	44.8078	2.1782	1.3322	0.9584	0.7442	0.7267	0.7095	0.6913	0.6703	0.6636	0.6560	0.6508	0.6467	0.6392	0.6365	0.6334
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
340.	P	62.746	62.710	62.669	62.586	62.244	62.136	61.974	61.704	61.159	60.923	60.605	60.356	60.155	59.764	59.613	59.446
	h	131.328	172.142	199.359	226.580	253.841	256.585	259.323	262.088	264.887	265.606	266.333	266.782	267.087	267.538	267.702	267.866
	s	0.19991	0.25095	0.28500	0.31906	0.35325	0.35671	0.36018	0.36372	0.36738	0.36835	0.36936	0.36999	0.37043	0.37112	0.37137	0.37162
	v	0.023	0.412	0.673	0.935	1.203	1.232	1.261	1.294	1.334	1.346	1.361	1.372	1.380	1.393	1.399	1.405
	d	44.3970	2.4249	1.4856	1.0700	0.8316	0.8120	0.7930	0.7728	0.7498	0.7427	0.7347	0.7290	0.7247	0.7178	0.7149	0.7118
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
350.	P	70.130	70.090	70.045	69.952	69.575	69.458	69.285	68.999	68.439	68.202	67.869	67.628	67.436	67.085	66.947	66.795
	h	136.678	176.906	203.728	230.554	257.432	260.138	262.835	265.556	268.334	269.030	269.754	270.197	270.483	270.945	271.100	271.252
	s	0.20652	0.25621	0.28934	0.32250	0.35579	0.35916	0.36254	0.36597	0.36955	0.37047	0.37145	0.37206	0.37247	0.37313	0.37336	0.37359
	v	0.023	0.372	0.605	0.839	1.079	1.105	1.131	1.160	1.196	1.206	1.219	1.228	1.234	1.245	1.249	1.254
	d	43.9796	2.6892	1.6528	1.1920	0.9267	0.9050	0.8841	0.8620	0.8364	0.8293	0.8204	0.8145	0.8106	0.8032	0.8005	0.7978
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
360.	P	78.152	78.107	78.057	77.953	77.518	77.392	77.206	76.905	76.331	76.095	75.789	75.557	75.375	75.048	74.921	74.783
	h	142.077	181.704	208.122	234.554	261.028	263.691	266.360	269.051	271.770	272.470	273.173	273.609	273.887	274.336	274.483	274.636
	s	0.21310	0.26145	0.29369	0.32596	0.35835	0.36163	0.36493	0.36828	0.37173	0.37264	0.37357	0.37416	0.37454	0.37516	0.37537	0.37559
	v	0.023	0.336	0.545	0.755	0.971	0.994	1.018	1.044	1.074	1.083	1.094	1.101	1.106	1.115	1.118	1.121
	d	43.5556	2.9746	1.8342	1.3238	1.0303	1.0064	0.9827	0.9581	0.9312	0.9230	0.9143	0.9081	0.9044	0.8969	0.8945	0.8917
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
370.	P	86.814	86.765	86.710	86.594	86.144	86.009	85.812	85.498	84.915	84.682	84.384	84.162	83.991	83.687	83.571	83.446
	h	147.524	186.533	212.544	238.569	264.642	267.262	269.882	272.541	275.216	275.905	276.591	277.021	277.296	277.728	277.874	278.025
	s	0.21966	0.26668	0.29805	0.32944	0.36095	0.36414	0.36733	0.37060	0.37394	0.37482	0.37571	0.37627	0.37664	0.37722	0.37743	0.37763
	v	0.023	0.305	0.493	0.682	0.875	0.896	0.917	0.940	0.967	0.975	0.984	0.990	0.994	1.001	1.003	1.006
	d	43.1252	3.2827	2.0296	1.4668	1.1425	1.1162	1.0907	1.0633	1.0343	1.0256	1.0167	1.0102	1.0063	0.9992	0.9966	0.9937

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-8, Saturation Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Quality

Temp		q 0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
380.	P	96.204	96.150	96.088	95.961	95.472	95.328	95.120	94.794	94.207	93.978	93.691	93.480	93.318	93.038	92.931	92.818
	h	153.026	191.398	216.995	242.595	268.245	270.822	273.409	276.017	278.658	279.336	280.012	280.424	280.708	281.129	281.274	281.412
	s	0.22620	0.27191	0.30240	0.33291	0.36355	0.36664	0.36976	0.37292	0.37617	0.37702	0.37788	0.37841	0.37878	0.37933	0.37952	0.37971
	v	0.023	0.277	0.446	0.616	0.790	0.809	0.828	0.849	0.872	0.879	0.887	0.891	0.895	0.901	0.903	0.905
	d	42.6860	3.6137	2.2406	1.6226	1.2653	1.2365	1.2079	1.1785	1.1466	1.1374	1.1280	1.1218	1.1170	1.1099	1.1073	1.1049
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
390.	P	106.334	106.275	106.207	106.067	105.539	105.386	105.168	104.832	104.245	104.021	103.745	103.545	103.394	103.135	103.038	102.935
	h	158.579	196.305	221.459	246.625	271.859	274.392	276.929	279.496	282.103	282.741	283.418	283.829	284.097	284.508	284.651	284.799
	s	0.23272	0.27713	0.30674	0.33638	0.36616	0.36917	0.37219	0.37526	0.37843	0.37921	0.38005	0.38057	0.38091	0.38144	0.38162	0.38181
	v	0.024	0.252	0.405	0.558	0.715	0.732	0.749	0.767	0.788	0.793	0.800	0.805	0.807	0.812	0.814	0.816
	d	42.2386	3.9654	2.4709	1.7922	1.3980	1.3665	1.3357	1.3034	1.2685	1.2603	1.2497	1.2428	1.2384	1.2313	1.2285	1.2254
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
400.	P	117.243	117.177	117.102	116.949	116.381	116.220	115.993	115.650	115.065	114.848	114.584	114.396	114.256	114.017	113.929	113.836
	h	164.187	201.244	225.945	250.662	275.451	277.942	280.447	282.972	285.516	286.165	286.820	287.224	287.489	287.899	288.024	288.160
	s	0.23922	0.28234	0.31108	0.33985	0.36876	0.37169	0.37463	0.37762	0.38066	0.38145	0.38225	0.38274	0.38307	0.38358	0.38374	0.38391
	v	0.024	0.230	0.368	0.506	0.648	0.663	0.678	0.695	0.713	0.718	0.724	0.728	0.730	0.734	0.735	0.737
	d	41.7818	4.3441	2.7194	1.9765	1.5438	1.5090	1.4743	1.4390	1.4025	1.3924	1.3817	1.3745	1.3699	1.3621	1.3601	1.3575
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
410.	P	128.968	128.896	128.814	128.646	128.037	127.869	127.634	127.285	126.708	126.499	126.248	126.072	125.942	125.723	125.643	125.559
	h	169.851	206.212	230.467	254.725	279.049	281.493	283.950	286.432	288.943	289.561	290.204	290.601	290.862	291.265	291.380	291.523
	s	0.24571	0.28753	0.31543	0.34334	0.37138	0.37422	0.37707	0.37997	0.38293	0.38367	0.38444	0.38492	0.38523	0.38572	0.38587	0.38604
	v	0.024	0.210	0.335	0.460	0.588	0.601	0.615	0.630	0.647	0.651	0.655	0.659	0.661	0.664	0.665	0.667
	d	41.3075	4.7513	2.9847	2.1741	1.7011	1.6632	1.6255	1.5869	1.5467	1.5371	1.5258	1.5182	1.5133	1.5051	1.5036	1.5003
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
420.	P	141.549	141.471	141.381	141.198	140.549	140.374	140.133	139.780	139.213	139.013	138.737	138.572	138.451	138.250	138.177	138.101
	h	175.575	211.228	234.995	258.792	282.638	285.030	287.442	289.874	292.335	292.960	293.587	293.959	294.215	294.610	294.724	294.864
	s	0.25219	0.29272	0.31975	0.34682	0.37400	0.37674	0.37951	0.38231	0.38517	0.38591	0.38665	0.38709	0.38740	0.38787	0.38801	0.38818
	v	0.025	0.193	0.305	0.419	0.534	0.546	0.559	0.572	0.587	0.591	0.595	0.597	0.599	0.602	0.603	0.604
	d	40.7901	5.1797	3.2740	2.3882	1.8720	1.8311	1.7897	1.7481	1.7048	1.6933	1.6812	1.6744	1.6692	1.6606	1.6590	1.6555
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
430.	P	154.982	154.897	154.798	154.599	153.909	153.727	153.480	153.126	152.571	152.379	152.156	152.002	151.891	151.708	151.641	151.573
	h	181.357	216.266	239.557	262.852	286.224	288.566	290.928	293.325	295.719	296.331	296.950	297.315	297.566	297.946	298.058	298.178
	s	0.25865	0.29790	0.32409	0.35029	0.37663	0.37928	0.38196	0.38469	0.38743	0.38814	0.38886	0.38929	0.38958	0.39003	0.39016	0.39030
	v	0.025	0.177	0.279	0.382	0.486	0.497	0.508	0.521	0.533	0.537	0.540	0.543	0.544	0.547	0.547	0.548
	d	40.2636	5.6431	3.5812	2.6210	2.0565	2.0119	1.9671	1.9208	1.8756	1.8633	1.8505	1.8432	1.8377	1.8293	1.8275	1.8250
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
440.	P	169.384	169.290	169.183	168.967	168.238	168.051	167.801	167.448	166.910	166.728	166.518	166.377	166.274	166.107	166.048	165.986
	h	187.204	221.353	244.128	266.916	289.780	292.093	294.396	296.724	299.082	299.689	300.271	300.628	300.874	301.230	301.357	301.491
	s	0.26511	0.30308	0.32840	0.35375	0.37922	0.38181	0.38439	0.38701	0.38968	0.39037	0.39104	0.39145	0.39173	0.39214	0.39229	0.39244
	v	0.025	0.163	0.255	0.348	0.443	0.453	0.463	0.474	0.485	0.488	0.491	0.493	0.494	0.496	0.497	0.498
	d	39.7251	6.1284	3.9153	2.8733	2.2585	2.2080	2.1602	2.1116	2.0617	2.0479	2.0361	2.0283	2.0225	2.0147	2.0116	2.0078
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
450.	P	184.765	184.663	184.546	184.314	183.548	183.357	183.104	182.754	182.237	182.065	181.870	181.740	181.646	181.495	181.441	181.385
	h	193.120	226.473	248.722	270.986	293.318	295.576	297.833	300.114	302.403	302.995	303.580	303.915	304.170	304.504	304.628	304.758
	s	0.27157	0.30824	0.33271	0.35720	0.38181	0.38431	0.38681	0.38934	0.39190	0.39256	0.39322	0.39360	0.39389	0.39427	0.39441	0.39456
	v	0.026	0.150	0.234	0.318	0.404	0.413	0.422	0.431	0.441	0.444	0.447	0.449	0.450	0.451	0.452	0.453
	d	39.1736	6.6462	4.2736	3.1455	2.4781	2.4234	2.3709	2.3179	2.2654	2.2507	2.2368	2.2296	2.2223	2.2152	2.2119	2.2079

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-8, Saturation Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Quality

Temp																
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
460.	P	201.173	201.063	200.935	200.685	199.884	199.690	199.438	199.094	198.599	198.439	198.258	198.138	198.053	197.916	197.868	197.818
	h	199.105	231.635	253.326	275.037	296.837	299.039	301.239	303.464	305.697	306.275	306.839	307.173	307.415	307.748	307.855	307.990
	s	0.27802	0.31340	0.33699	0.36062	0.38438	0.38679	0.38920	0.39164	0.39410	0.39474	0.39537	0.39574	0.39601	0.39638	0.39650	0.39665
	v	0.026	0.139	0.215	0.290	0.368	0.376	0.385	0.393	0.402	0.405	0.407	0.408	0.410	0.411	0.411	0.412
	d	38.6089	7.1931	4.6608	3.4427	2.7164	2.6572	2.6004	2.5433	2.4868	2.4711	2.4569	2.4485	2.4415	2.4331	2.4308	2.4261
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
470.	P	218.658	218.538	218.343	218.131	217.239	217.044	216.792	216.456	215.984	215.834	215.667	215.557	215.480	215.356	215.313	215.268
	h	205.165	236.832	257.966	279.088	300.333	302.477	304.619	306.761	308.961	309.497	310.046	310.398	310.607	310.959	311.063	311.168
	s	0.28448	0.31855	0.34129	0.36403	0.38693	0.38925	0.39157	0.39390	0.39629	0.39688	0.39748	0.39787	0.39810	0.39848	0.39860	0.39871
	v	0.026	0.129	0.197	0.266	0.336	0.344	0.351	0.358	0.367	0.369	0.371	0.372	0.373	0.375	0.375	0.375
	d	38.0282	7.7764	5.0707	3.7641	2.9747	2.9108	2.8494	2.7903	2.7272	2.7128	2.6976	2.6862	2.6811	2.6698	2.6673	2.6648
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
480.	P	237.188	237.058	236.909	236.621	235.758	235.563	235.314	234.989	234.544	234.405	234.252	234.152	234.082	233.971	233.933	233.893
	h	211.312	242.075	262.598	283.132	303.781	305.864	307.946	310.027	312.165	312.699	313.221	313.551	313.766	314.096	314.198	314.299
	s	0.29096	0.32370	0.34555	0.36742	0.38944	0.39167	0.39390	0.39613	0.39843	0.39901	0.39957	0.39993	0.40016	0.40052	0.40063	0.40074
	v	0.027	0.119	0.181	0.243	0.307	0.314	0.320	0.327	0.334	0.336	0.338	0.339	0.340	0.341	0.341	0.342
	d	37.4276	8.3861	5.5204	4.1113	3.2581	3.1891	3.1228	3.0590	2.9912	2.9748	2.9594	2.9488	2.9419	2.9313	2.9285	2.9258
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
490.	P	256.952	256.811	256.650	256.344	255.458	255.263	255.020	254.709	254.291	254.164	254.025	253.935	253.872	253.773	253.739	253.704
	h	217.540	247.355	267.247	287.146	307.177	309.174	311.213	313.242	315.303	315.810	316.328	316.635	316.856	317.164	317.263	317.362
	s	0.29744	0.32885	0.34980	0.37077	0.39190	0.39402	0.39618	0.39833	0.40052	0.40106	0.40161	0.40194	0.40218	0.40251	0.40261	0.40272
	v	0.027	0.111	0.167	0.223	0.280	0.286	0.292	0.298	0.305	0.306	0.308	0.309	0.310	0.311	0.311	0.311
	d	36.8085	9.0331	6.0032	4.4923	3.5692	3.4974	3.4233	3.3529	3.2817	3.2650	3.2475	3.2371	3.2288	3.2185	3.2155	3.2125
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
500.	P	277.955	277.732	277.629	277.234	276.328	276.136	275.900	275.603	275.214	275.098	274.971	274.890	274.834	274.746	274.715	274.684
	h	223.873	252.687	271.909	291.160	310.504	312.455	314.406	316.378	318.359	318.840	319.372	319.669	319.861	320.149	320.266	320.362
	s	0.30396	0.33399	0.35403	0.37411	0.39430	0.39634	0.39839	0.40046	0.40254	0.40305	0.40361	0.40392	0.40412	0.40443	0.40455	0.40465
	v	0.028	0.103	0.153	0.204	0.256	0.261	0.266	0.272	0.278	0.279	0.281	0.282	0.282	0.283	0.283	0.284
	d	36.1626	9.7099	6.5228	4.9020	3.9115	3.8313	3.7541	3.6773	3.6019	3.5853	3.5627	3.5516	3.5451	3.5354	3.5298	3.5266
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
510.	P	300.157	299.992	299.806	299.462	298.545	298.358	298.132	297.851	297.494	297.388	297.275	297.203	297.153	297.075	297.048	297.021
	h	230.309	258.059	276.588	295.137	313.755	315.644	317.552	319.414	321.334	321.826	322.298	322.576	322.761	323.079	323.172	323.264
	s	0.31051	0.33914	0.35825	0.37739	0.39663	0.39859	0.40056	0.40249	0.40449	0.40500	0.40549	0.40578	0.40598	0.40631	0.40640	0.40650
	v	0.028	0.096	0.141	0.187	0.233	0.238	0.243	0.248	0.253	0.254	0.255	0.256	0.257	0.258	0.258	0.258
	d	35.4908	10.4269	7.0790	5.3518	4.2897	4.2024	4.1153	4.0376	3.9556	3.9339	3.9147	3.9041	3.8971	3.8819	3.8784	3.8750
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
520.	P	323.798	323.620	323.422	323.061	322.064	321.884	321.668	321.405	321.079	320.984	320.883	320.819	320.775	320.707	320.683	320.660
	h	236.875	263.497	281.251	299.039	316.933	318.754	320.576	322.364	324.196	324.678	325.123	325.399	325.585	325.852	325.979	326.068
	s	0.31712	0.34430	0.36243	0.38060	0.39890	0.40076	0.40263	0.40446	0.40635	0.40684	0.40730	0.40758	0.40777	0.40805	0.40818	0.40827
	v	0.029	0.090	0.130	0.171	0.212	0.217	0.221	0.225	0.230	0.231	0.232	0.233	0.233	0.234	0.235	0.235
	d	34.7831	11.1725	7.6913	5.8542	4.7065	4.6111	4.5192	4.4353	4.3483	4.3242	4.3049	4.2921	4.2830	4.2717	4.2633	4.2595
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
530.	P	348.776	348.585	348.374	347.997	347.080	346.908	346.706	346.464	346.170	346.086	345.998	345.942	345.904	345.845	345.825	345.804
	h	243.573	268.970	285.930	302.909	319.989	321.733	323.433	325.180	326.930	327.356	327.816	328.071	328.241	328.512	328.632	328.718
	s	0.32378	0.34945	0.36659	0.38376	0.40105	0.40281	0.40454	0.40631	0.40809	0.40852	0.40899	0.40925	0.40942	0.40970	0.40982	0.40991
	v	0.029	0.084	0.120	0.156	0.193	0.197	0.201	0.205	0.209	0.210	0.211	0.211	0.212	0.213	0.213	0.213
	d	34.0407	11.9715	8.3468	6.4012	5.1737	5.0699	4.9775	4.8808	4.7873	4.7664	4.7409	4.7285	4.7203	4.7052	4.6965	4.6924

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

Table B-8. Saturation Thermodynamic Properties of Partially Degraded Toluene at Even Increments of Temperature and Quality

Temp																
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
540.	P	375.270	375.065	374.842	374.450	373.548	373.387	373.200	372.980	372.718	372.645	372.568	372.520	372.487	372.436	372.419	372.401
	h	250.441	274.518	290.593	306.693	322.914	324.539	326.196	327.840	329.500	329.904	330.340	330.597	330.759	331.002	331.082	331.163
	s	0.33054	0.35463	0.37071	0.38683	0.40308	0.40471	0.40637	0.40802	0.40969	0.41010	0.41053	0.41079	0.41096	0.41120	0.41128	0.41136
	v	0.030	0.078	0.110	0.143	0.176	0.179	0.182	0.186	0.189	0.190	0.191	0.192	0.192	0.193	0.193	0.193
	d	33.2483	12.8003	9.0668	7.0134	5.6962	5.5900	5.4827	5.3821	5.2819	5.2592	5.2321	5.2159	5.2070	5.1937	5.1893	5.1849
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
550.	P	403.369	403.150	402.914	402.512	401.639	401.490	401.320	401.124	400.896	400.833	400.767	400.726	400.698	400.656	400.641	400.626
	h	257.517	280.141	295.238	310.395	325.649	327.165	328.751	330.282	331.801	332.241	332.635	332.863	333.015	333.243	333.319	333.395
	s	0.33742	0.35983	0.37479	0.38981	0.40494	0.40644	0.40802	0.40954	0.41105	0.41149	0.41188	0.41210	0.41226	0.41248	0.41256	0.41263
	v	0.031	0.073	0.101	0.130	0.159	0.162	0.165	0.168	0.171	0.172	0.173	0.173	0.173	0.174	0.174	0.174
	d	32.3963	13.6621	9.8597	7.6943	6.2911	6.1802	6.0608	5.9545	5.8546	5.8210	5.7939	5.7795	5.7699	5.7555	5.7508	5.7460
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
560.	P	433.192	432.959	432.712	432.306	431.478	431.344	431.194	431.024	430.831	430.778	430.723	430.690	430.666	430.631	430.620	430.608
	h	264.844	285.844	299.883	313.954	328.125	329.534	331.008	332.431	333.843	334.196	334.549	334.761	334.958	335.183	335.254	335.325
	s	0.34446	0.36506	0.37883	0.39264	0.40656	0.40794	0.40939	0.41079	0.41218	0.41253	0.41287	0.41308	0.41328	0.41350	0.41357	0.41364
	v	0.032	0.069	0.093	0.118	0.143	0.146	0.148	0.151	0.154	0.154	0.155	0.155	0.156	0.156	0.156	0.156
	d	31.4755	14.5874	10.7276	8.4710	6.9811	6.8621	6.7350	6.6210	6.5134	6.4871	6.4609	6.4454	6.4261	6.4078	6.4027	6.3976
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
570.	P	464.798	464.551	464.298	463.895	463.077	463.025	462.898	462.758	462.601	462.559	462.516	462.490	462.471	462.444	462.435	462.426
	h	272.546	291.675	304.445	317.313	330.232	331.519	332.827	334.164	335.503	335.826	336.148	336.342	336.495	336.688	336.753	336.817
	s	0.35179	0.37037	0.38278	0.39528	0.40784	0.40909	0.41037	0.41167	0.41297	0.41329	0.41360	0.41379	0.41394	0.41413	0.41419	0.41425
	v	0.033	0.064	0.085	0.107	0.128	0.130	0.133	0.135	0.137	0.138	0.138	0.139	0.139	0.139	0.139	0.139
	d	30.4424	15.5489	11.7164	9.3741	7.8003	7.6732	7.5443	7.4162	7.2919	7.2636	7.2356	7.2188	7.2020	7.1854	7.1799	7.1744
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
580.	P	498.494	498.237	497.982	497.601	496.864	496.771	496.671	496.563	496.445	496.414	496.382	496.362	496.349	496.329	496.323	496.316
	h	280.769	297.660	308.981	320.281	331.799	332.939	334.078	335.216	336.377	336.662	336.948	337.118	337.254	337.520	337.577	337.634
	s	0.35953	0.37578	0.38667	0.39754	0.40863	0.40973	0.41083	0.41193	0.41305	0.41332	0.41359	0.41376	0.41389	0.41415	0.41420	0.41426
	v	0.034	0.060	0.078	0.095	0.114	0.115	0.117	0.119	0.121	0.121	0.122	0.122	0.122	0.123	0.123	0.123
	d	29.2622	16.5893	12.8386	10.4832	8.8091	8.6740	8.5430	8.4158	8.2866	8.2563	8.2263	8.2083	8.1907	8.1558	8.1499	8.1440
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
590.	P	534.395	534.133	533.891	533.555	533.054	532.989	532.921	532.849	532.773	532.754	532.734	532.722	532.714	532.701	532.697	532.693
	h	290.013	303.974	313.293	322.760	332.208	333.151	334.254	335.198	336.146	336.383	336.620	336.763	336.857	337.000	337.047	337.094
	s	0.36814	0.38145	0.39033	0.39935	0.40836	0.40926	0.41031	0.41121	0.41211	0.41234	0.41257	0.41270	0.41279	0.41293	0.41297	0.41302
	v	0.036	0.056	0.070	0.084	0.098	0.099	0.101	0.103	0.104	0.104	0.105	0.105	0.105	0.105	0.105	0.105
	d	27.7713	17.7074	14.2617	11.8882	10.2024	10.0606	9.8882	9.7543	9.6237	9.5916	9.5597	9.5407	9.5281	9.5092	9.5029	9.4966
	q	0.000	0.300	0.500	0.700	0.900	0.920	0.940	0.960	0.980	0.985	0.990	0.993	0.995	0.998	0.999	1.000
600.	P	573.365	573.139	572.962	572.956	572.497	572.469	572.440	572.410	572.571	572.564	572.556	572.551	572.548	572.542	572.542	572.347
	h	302.544	311.481	317.381	322.977	329.402	330.518	331.128	331.739	331.802	331.952	332.102	332.192	332.252	332.342	332.372	332.960
	s	0.37975	0.38818	0.39375	0.39903	0.40510	0.40615	0.40673	0.40730	0.40736	0.40750	0.40764	0.40773	0.40778	0.40787	0.40790	0.40846
	v	0.040	0.053	0.061	0.069	0.078	0.080	0.081	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.082	0.083
	d	24.8981	18.9430	16.3453	14.5034	12.7872	12.5085	12.3744	12.2431	12.2563	12.2245	12.1930	12.1741	12.1616	12.1428	12.1366	11.9887

T in F, P in psia, h in Btu/lb, s in Btu/lb-R, v in cubic feet/lb, d in lb/cubic foot

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15. Supplementary Notes

Project Manager, Myron E. Hill, Solar Dynamic Power Module Division, NASA Lewis Research Center. Appendix D - Thermodynamic Properties of Toluene and Partially Degraded Toluene After Exposure to 750 °F in a Rankine Cycle for Extended Periods of Time by L.V. Jasperson, W.V. Wilding, H.L. Wilson, L.C. Wilson, and G.M. Wilson.

16. Abstract

The design, fabrication, assembly, and endurance operation of a dynamic test loop, built to evaluate the thermal stability of a proposed Organic Rankine Cycle (ORC) working fluid, is discussed. The test fluid, toluene, was circulated through a heater, simulated turbine, regenerator, condenser and pump to duplicate an actual ORC system. The maximum nominal fluid temperature, 750 °F, was at the turbine simulator inlet. Samples of noncondensible gases and liquid toluene were taken periodically during the test. The samples were analyzed to identify the degradation products formed and the quantity of these products. From these data it was possible to determine the degradation rate of the working fluid and the generation rate of noncondensible gases. A further goal of this work was to relate the degradation observed in the dynamic operating loop to degradation obtained in isothermal capsule tests. This relationship was the basis for estimating the power loop degradation in the Space Station Organic Rankine Cycle system.

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