Enthalpies of Benzene and Mixtures of Benzene with *n*-Octane

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A flow calorimeter has been used to measure the enthalpy of benzene and six mixtures of the benzene–*n*-octane system. The results are tabulated from 380° to 700° F mixtures, with pressures ranging up to 1400 psia.

Experimental measurements have been made for mixtures of benzene and *n*-octane, a system that exhibits a minimum of 548° F in the critical locus as the composition varies (*10*). No report of previous enthalpy measurements has been found for this mixture, although enthalpies have been presented for the pure components. The enthalpy of pure *n*-octane has been measured (*12*) and also computed (*7*). Numerous thermal measurements have been made with pure benzene. Burlew (*4*) summarized the available heat capacity data on liquid benzene below 176° F, and presented the results of his own measurements using a piezothermometric method. Heats of vaporization are presented by Connolly and Kandalic (*6*), Gottschal and Korvezee (*9*), and Osborne and Ginnings (*17*). Enthalpy values are available from the work of Gilliland et al. (*8*), Kemp (*11*), Lindsay and Brown (*13*), and Riediger (*18*). Organick and Studhalter (*16*) computed enthalpy values from an equation of state, included the available thermal information in the literature prior to 1948, and presented a comprehensive table of benzene enthalpy values. Canjar and Manning (*5*) reviewed the benzene information, and, in 1967, published benzene enthalpy values relying mainly on the previous presentation of Organick and Studhalter. This present paper shows the results of new measurements in benzene, taken mostly in the critical region. The values reported do not depend upon an equation of state.

The measurements were made using a flow calorimeter, whose construction and operation were previously discussed. Briefly, the calorimeter measures the difference in enthalpy between a measured inlet condition and a fixed outlet temperature of 75° F and the liquid state. The calorimeter operates isobarically. A total of 1300 measurements were made showing the enthalpy differences at the pressure of measurement. These results are tabulated and deposited with ASIS (*3*).

During the measurements, the calorimeter was used at intervals to measure the enthalpy of liquid water and gaseous *n*-pentane. Comparison with literature enthalpy values for water (*15*), and *n*-pentane (*2*) showed that the average deviation between measured and published values was within 1.5 Btu/lb. This accuracy of measurement has been maintained by the calorimeter since its development.

The measured enthalpy values were converted to a zero enthalpy basis of −200° F and the saturated liquid state of the pure components in conformity with the American Petroleum Institute data book (*1*). For benzene, the enthalpy values based on 75° F and the saturated liquid were plotted as a function of pressure for the 460°, 540°, 580°, and 660° F isotherms to determine the zero pressure enthalpy for each temperature by extrapolation. It was determined that 88.1 Btu/lb was needed on the average to be added to zero pressure enthalpies to agree with the enthalpies presented in Table 7A1.3 of the American Petroleum Institute data book. Since benzene solidifies at 42° F, the exact meaning of the enthalpy at −200° F and the saturated liquid condition appears dubious, but the results are consistent with the data book presentation, which is the intent. The enthalpy difference needed for *n*-octane to be converted to the −200° F basis was previously determined at 115.3 Btu/lb (*12*). For the mixtures, the enthalpy needed to convert the data based on the saturated liquid at 75° F to the −200° F basis is a weight average of the values for the pure components, plus the heat of mixing at 75° F in the liquid phase. Heats of mixing were obtained from the work of Lundberg (*14*). Since the data are obtained at the pressure of measurement, all the measurements were placed on a common preliminary base level at 75° F and the saturated liquid state. The difference in enthalpy for the liquid between the pressure of measurement and the saturated liquid condition was computed using the thermodynamic equation of state, and measured liquid densities at 70°, 75°, and 80° F at atmospheric pressures. This correction never exceeds 4 Btu/lb and is evaluated with more preciseness than the accuracy of measurement, as previously discussed (*12*).

Both the *n*-octane and benzene were obtained from the

Table I. Properties of Liquid Phase at 75° F and 1 Atm

Material	Benzene, wt %	Density, g/cc	Heat of mixing, Btu/lb	H needed for −200° F basis, Btu/lb
Benzene	100	0.8730	0	88.1
93.0 mol % benzene	90.1	0.8505	1.8	92.6
85.7 mol % benzene	80.3	0.8312	3.1	96.6
77.1 mol % benzene	69.7	0.8082	4.2	100.7
67.6 mol % benzene	58.8	0.7895	4.7	104.3
44.6 mol % benzene	35.6	0.7492	4.2	110.2
27.1 mol % benzene	20.2	0.7252	2.9	113.3
n-Octane	0	0.7000	0	115.3

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Table II. Values of Enthalpy for Pure Benzene

Units. Btu/lb
Datum. Pure saturated liquid benzene at −200° F

Temp, ° F	Psia											
	0	200	400	500	600	650	700	714	750	800	1000	1400
380	375.3	236.7										
400	383.6	369.3	248.1									
420	392.1	378.0	259.9									
440	400.6	387.0	272.1									
460	409.3	396.2	285.0									
480	417.6	405.7	390.5	298.0								
500	426.2	415.1	401.3	311.7							307.9	306.6
520	435.1	424.7	412.1	403.5	326.7						320.9	319.1
530	439.7	429.6	417.4	409.7	394.3	334.6					327.7	325.8
540	444.3	434.3	422.7	415.1	403.8	390.7	343.6		340.3	337.5	334.7	332.3
544	446.0	436.2	424.9	417.3	406.8	397.4	348.0		344.2	341.0	338.3	335.0
546	447.0	437.2	425.9	418.4	408.3	399.9	350.2		346.2	342.8	339.0	336.3
548	447.8	438.0	427.0	419.5	409.8	402.0	353.1		348.0	344.6	340.3	337.6
550	448.9	439.0	428.0	420.6	411.0	404.0	388.2	357.5	350.2	346.7	341.9	338.9
552	449.7	440.0	429.0	421.7	412.2	405.8	392.8	369.0	353.1	349.0	343.2	340.1
554	450.5	440.9	430.0	422.9	413.8	407.5	396.1	387.0	356.9	351.1	344.9	341.7
556	451.4	441.9	431.1	423.9	415.0	409.0	398.8	391.9	362.8	353.7	346.2	342.9
558	452.3	442.9	432.1	425.0	416.2	410.5	401.1	395.4	374.3	356.2	348.0	344.2
560	453.2	443.9	433.1	426.1	417.5	411.9	403.4	398.6	385.1	359.5	349.9	345.7
565	455.5	446.2	435.8	429.0	420.8	415.2	408.2	404.0	397.0	367.9	354.0	349.0
570	457.9	448.8	438.5	431.8	423.9	418.7	412.6	408.8	403.5	378.1	358.1	352.5
580	462.3	453.7	443.9	437.2	430.0	425.3	420.5	417.3	413.5	405.1	367.0	359.7
600	471.5	463.3	454.1	448.2	441.6		434.2		429.7	425.2	389.8	373.6
620	481.2	473.0	464.4	459.1	453.1		447.0			440.0	415.2	388.6
640	491.0	482.9	474.8	470.1	465.0		459.4			453.4	435.1	405.0
660	500.6	492.8	485.0	481.1	476.5		471.6			466.2	451.1	422.5
680	510.0	503.0	495.2	491.8	487.5		483.1			478.8	466.5	440.0
700	519.5	513.0	505.7	502.2	498.5		494.6			490.6	481.0	457.0

Table III. Saturated Enthalpy Values for Pure Benzene

Units. Btu/lb
Base level. Saturated supercooled liquid benzene at −200° F

Temp, ° F	Press, psia	Liquid enthalpy	Vapor enthalpy
285.6	70	185.7	332.9
317.2	100	202.1	342.3
387.2	200	240.7	363.8
471.1	400	292.0	385.8
501.7	500	312.8	390.8
527.5	600	332.5	391.2
539.1	650	342.8	388.5
545.2	680	349.7	385.6
549.2	700	355.3	381.4
550.8	708	359.4	378.0
552.0	714	369.0	369.0

Table IV. Comparison of Benzene Enthalpy Values at 560° F

Enthalpy difference, H° − H, Btu/lb

	Psia							
	200	400	500	600	700	800	1000	1400
This work	9.4	20.0	27.0	35.7	49.7	93.6	103.5	107.6
Canjar (5)	9.0	20.6	27.9	37.2	51.8	98.9	107.9	112.9
Kemp (11)	8.7	19.1	25.7	35.2		93.5	105.0	110.5
API data book (1)	9.1	23.0	30.4	38.6		89.6	105.1	109.5

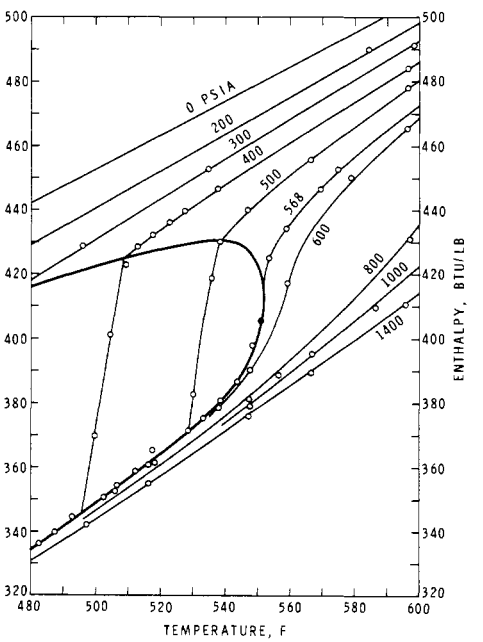

Figure 1. Enthalpy of 58.8 wt % benzene with *n*-octane

Phillips Petroleum Co. as their pure grade, and used as received. The *n*-octane was specified to have a purity of 99.0% or better, with measured density at 75° F of 0.7000 g/cc, and refractive index of n_D^{20} = 1.3977. The benzene purity was stated to exceed 99.0%. The density was 0.8730 g/cc, with refractive index of n_D^{20} = 1.50030. The American Petroleum Institute shows corresponding values of 0.700 and 1.39743 for *n*-octane, with 0.8749 and 1.50112 for benzene. Table I shows the compositions of the materials studied in both mole and weight percent, the liquid density at 75° F and atmospheric pressure, the heat of mixing, and the enthalpy needed to convert (1) the measurements based on 75° F and (2) the saturated liquid condition to the −200° F basis.

By crossplotting on large-scale graph paper, smoothed values of enthalpy have been obtained that differ from the measured values by a standard error of estimate of 1.1 Btu/lb including the results for benzene alone and the

Table V. Values of Enthalpy for Mixture of 90.1 Wt % Benzene with 9.9 Wt % *n*-Octane

Units. Btu/lb
Datum. Pure saturated liquid components at −200° F

	Psia										
Temp, ° F	0	200	300	400	500	600	675	700	800	1000	1400
380	379.3	244.4									243.4
391.2		251.4[a]									
396.2		371.7[a]									
400	388.0	373.6	256.6								254.8
420	396.5	383.0	268.6								266.4
438.0			280.1[a]								
440	405.5	392.5	324.3	281.5							278.3
443			385.1[a]								
460	414.4	402.2	393.8	294.3							290.3
474.4				303.8[a]							
479.0				394.5[a]							
480	423.5	411.9	404.0	395.0	307.6						302.5
500	432.6	421.7	414.6	407.0	321.3			320.0	318.3	316.6	315.0
504.6					324.6[a]						
509.0					401.1[a]						
520	442.1	431.6	425.1	418.6	408.4	335.8	334.6	334.0	332.3	330.6	328.0
532.3						346.0[a]					
536.3						403.4[a]					
540	452.1	441.8	436.0	429.9	422.0	406.6	353.3	350.7	347.6	344.9	341.3
545					425.1	411.1	360.2	356.9	351.8	348.9	344.6
550					428.3	415.6	376.6[b]	366.6	356.1	352.6	347.9
552					429.6	417.4	398.1	374.8	358.2	354.0	349.3
555					431.5	419.9	405.1	395.5	361.3	356.2	351.4
560	460.8	451.9	446.7	441.4	434.5	423.9	411.1	407.0	366.9	360.1	354.7
570					440.5	431.6	419.5	417.1	381.7	368.6	361.6
580	470.3	462.3	457.6	452.5	446.3	438.0	427.6	425.1	403.7	377.2	368.1
600	479.5	472.7	468.6	463.7	457.6	450.3	443.0	440.6	427.0	397.0	381.9

[a] On two-phase boundary. [b] At critical point.

Table VI. Values of Enthalpy for Mixture of 80.3 Wt % Benzene with 19.7 Wt % *n*-Octane

Units. Btu/lb
Datum. Pure saturated liquid components at −200° F

	Psia										
Temp, ° F	0	200	300	400	500	600	640	700	800	1000	1400
380	384.1	251.9									251.2
395.4		261.6[a]									
400	392.9	315.2	264.6								263.3
405.3		379.9[a]									
420	401.9	386.8	276.8								275.7
440	411.1	396.1	289.7								287.9
442.5			290.5[a]								
451.7			394.2[a]								
460	420.4	406.2	398.8	302.1							300.1
480	430.0	416.6	409.2	315.4							312.4
480.3				315.6[a]							
488.0				403.4[a]							
500	439.3	427.2	420.1	411.1	329.5				326.8		324.7
510.7					337.2[a]						
519.8					409.9[a]						
520	448.8	437.9	431.2	423.5	410.1	344.6		342.6	341.2	339.9	337.7
536						358.4[a]					
540	458.5	448.8	442.4	435.4	426.1	383.0	362.4	359.8	357.2	354.8	350.9
544.3						409.2[a]					
545					429.6	410.5	368.3	364.8	361.7	358.6	354.1
550					433.1	418.1	384.7[b]	370.2	366.2	362.4	357.4
551					433.8	419.4	395.9	371.2	367.2	363.1	
552					434.6	420.6	402.7	372.4	368.1	363.9	
554					435.9	422.8	409.2	374.9	370.1	365.4	
556					437.3	424.8	412.6	377.7	372.1	366.9	
560	468.4	459.6	453.7	447.6	439.9	428.6	418.0	384.8	376.4	369.8	364.1
565					443.5	433.0	423.6	403.0	382.1	374.1	367.6
570					446.8	436.9	428.6	414.9	388.3	378.4	370.9
580	478.3	470.4	465.1	459.6	453.3	444.2	437.3	428.0	402.9	386.9	377.8
600	487.9	481.4	476.5	471.6	465.9	457.4	452.4	445.2	429.6	405.0	391.7

[a] On two-phase boundary. [b] At critical point.

Table VII. Values of Enthalpy for Mixture of 69.7 Wt % Benzene with 30.3 Wt % *n*-Octane

Units. Btu/lb
Datum. Pure saturated liquid components at −200° F

	Psia									
Temp, ° F	0	200	300	400	500	600	700	800	1000	1400
380	388.7	260.6								260.6
400	398.0	272.8								272.1
400.7		273.1[a]								
415.6		388.6[a]								
420	407.3	391.1	285.0							284.0
440	416.8	401.6	298.6							296.2
449.9			305.5[a]							
460	426.4	412.6	393.8	312.3						308.6
461.2			403.6[a]							
480	436.2	423.4	414.6	325.9						321.5
486.8				331.0[a]						
497.0				413.7[a]						
500	446.1	434.1	426.1	416.7	340.6					334.7
520	456.2	445.0	437.5	429.7	355.7		352.8	351.2	350.1	348.2
520.4					356.6[a]					
530.0					420.7[a]					
540	466.1	455.9	448.9	442.1	430.6	374.0	369.0	366.7	364.2	361.7
545				445.0	434.6	381.2	373.2	370.9		
550				447.9	438.3	394.0[b]	377.9	375.3	371.8	368.4
551				448.5	439.0	403.7	378.9	376.3		
552				449.1	439.7	417.9	380.0	377.1		
554				450.3	441.2	424.1	381.8	378.9		
560	476.3	467.1	460.4	453.7	445.3	432.6	389.4	384.5	379.6	375.3
565				456.7	448.6	437.8	398.3	389.5	383.6	378.7
570				459.6	452.0	442.3	411.3	394.6	387.8	382.1
580	486.3	477.8	471.7	465.5	458.7	450.3	431.2	405.3	396.0	390.0
600	496.9	488.5	483.1	477.0	470.7	464.0	451.2	432.4	414.0	402.6

[a] On two-phase boundary. [b] At critical point.

Table VIII. Values of Enthalpy for Mixture of 58.8 Wt % Benzene with 41.2 Wt % *n*-Octane

Units. Btu/lb
Datum. Pure saturated liquid components at −200° F

	Psia									
Temp, ° F	0	200	300	400	500	568	600	800	1000	1400
380	393.3	266.8								267.9
400	402.7	279.4								280.3
408.7		285.1[a]								
420	412.4	359.5	292.8							292.8
427.4		398.9[a]								
440	422.3	406.0	306.2							305.5
459.5			319.9[a]							
460	432.0	417.6	324.2	320.1						318.1
473.2			413.8[a]							
480	442.2	429.2	418.0	334.2						330.8
495.7				345.6[a]						
500	452.3	440.7	430.7	371.5	348.6		347.1			344:0
508.5				424.4[a]						
520	462.9	452.1	443.1	433.8	364.0		362.5	360.4	359.3	357.7
528.8					371.6[a]					
538.3					430.3[a]					
540	473.6	463.4	455.5	447.7	432.3	382.5	380.6	376.1	374.1	371.5
545				450.9	437.9	389.0	386.6	380.0	377.9	375.0
550				454.3	442.6	400.2	393.6	384.3	381.9	378.7
551						405.1[b]				
552				455.7	444.3	412.4	396.9	386.0	383.4	380.0
554				456.8	446.1	426.3	400.9	387.8	384.9	381.4
556				458.2	447.5	429.8	405.9	389.6	386.6	382.7
560	484.4	474.9	467.7	460.7	450.6	435.3	419.5	393.2	389.8	385.7
570				467.2	458.4	447.3	438.2	402.6	397.7	392.8
580	495.2	486.5	479.9	473.6	465.7	456.9	450.2	412.9	405.7	399.8
600	506.2	498.3	492.3	486.2	480.2	473.0	469.3	435.2	422.4	414.1

[a] On two-phase boundary. [b] At critical point.

Table IX. Values of Enthalpy for Mixture of 35.6 Wt % Benzene with 64.4 Wt % *n*-Octane

Units. Btu/lb
Datum. Pure saturated liquid components at −200° F

	Psia											
Temp, ° F	0	200	400	400	450	483	500	600	700	800	1000	1400
380	403.2	282.6										283.9
400	413.7	295.8										297.1
420	423.9	309.5										310.2
432.4		318.2[a]										
440	434.4	357.3	323.4									323.4
450.7		421.2[a]										
460	445.5	427.2	337.9									336.5
480	456.3	440.0	352.7									349.9
482.3			354.5[a]									
497.9			438.3[a]									
500	467.7	452.4	439.8	368.3				366.2				363.7
520	478.9	464.6	453.3	384.5			383.5	381.5		380.8	379.3	377.9
521.0				385.4[a]								
535.8				449.1[a]								
537.8					400.2[a]							
540	480.7	477.0	466.3	452.8	409.0	401.9	400.3	397.2	396.6	395.8	394.4	392.3
549.3					450.4[a]							
550	496.6	483.3	472.9	461.3	451.4	413.4	410.5	405.5	404.9	403.6	401.8	399.4
553			475.0	463.7	454.9	418.8	414.6	408.2	407.5			
555			476.3	465.4	457.2	425.1[b]	418.9	410.0	409.2			
558			478.3	467.9	460.2	436.1	430.9	412.9	411.7			
560	502.2	489.4	479.7	469.4	462.1		440.1	414.8	413.4	411.5	409.5	406.5
563			481.6	471.8	464.8		449.6	417.9	416.0			
566			483.7	473.9	467.5		454.5	421.2	418.6			
570			486.3	476.9	470.8		459.6	426.4	422.3			
580	512.8	501.7	493.1	484.5	478.9		469.9	443.6	431.3	427.9	425.2	421.1
600	525.4	514.3	406.6	506.6	493.3		487.2	469.1	450.1	445.1	441.9	436.0

[a] On two-phase boundary. [b] At critical point.

Table X. Values of Enthalpy for Mixture of 20.2 Wt % Benzene with 79.8 Wt % *n*-Octane

Units. Btu/lb
Datum. Pure saturated liquid components at −200° F

	Psia										
Temp, ° F	0	200	300	400	433	500	600	700	800	1000	1400
380	409.8	292.3									292.3
400	421.1	306.4									305.5
420	431.8	320.6									318.9
440	443.0	335.2									332.6
450.9		343.1[a]									
460	454.2	380.9	349.8								346.8
467.0		436.9[a]									
480	466.1	445.6	364.8								361.0
499.3			380.1[a]								
500	477.6	459.1	381.9	380.7					377.0		375.4
513.4			454.6[a]								
520	489.6	472.4	459.7	398.7					392.4	391.4	390.1
540	501.5	485.7	475.5	415.4		413.5	410.8	409.3	408.0	406.4	404.7
542.2				417.5[a]							
550		492.4	483.0	460.0	425.4	422.8	418.8	417.4			
550.5				463.1[a]							
555		495.8	486.8	469.8	431.7	427.5	423.1	421.4			
559		498.4	489.7	474.4	437.8[b]	431.5	426.4	424.7			
560	514.0	499.0	490.4	475.4	440.0	432.4	427.4	425.5	424.1	422.3	419.8
561		499.8	491.2	476.5	442.7	433.5	428.2	426.4			
562.5			492.4	478.0	451.5	435.0	429.6	427.7			
570		505.6	497.8	485.0		444.8	436.0	434.0			
575		509.0	501.4	489.4		454.0	440.5	438.5			
580	526.1	512.4	504.9	493.6		466.0	445.2	442.8	440.6	438.0	434.8
600	538.6	525.4	519.1	509.4		491.3	472.5	461.5	457.7	454.2	450.4

[a] On two-phase boundary. [b] At critical point.

benzene-octane mixtures. Table II shows smoothed enthalpies for pure benzene, from 380° to 700° F. Table III shows saturated liquid and vapor enthalpies from 70 psia to the critical pressure of 714 psia. Figure 1 illustrates graphically the enthalpy behavior for the mixture with 58.8 wt % benzene. Table IV shows the predicted enthalpy difference at 560° F between the real gas enthalpy and that of the ideal gas as shown by this work, and by three other sources (*1, 5, 11*). The temperature of 560° F is only 8° F higher than the critical temperature, and represents an isotherm where considerable nonideality exists in the gas phase. The discrepancies are moderate, but become somewhat larger at higher pressures, showing a maximum deviation of 5.3 Btu/lb.

Tables V–X show smoothed enthalpies for the 90.1, 80.3, 69.7, 58.8, 35.6, and 20.2 wt % benzene in octane mixtures. These include saturated enthalpies and also denote the enthalpy at the critical point, obtained from the measurements of Kay and Hissong (*10*) on the benzene–*n*-octane system.

LITERATURE CITED

(1) American Petroleum Institute, Division of Refining, "Technical Data Book. Petroleum Refining," Section 7A1.3, New York, N. Y., 1966.
(2) American Petroleum Institute Research Project 44, "Selected Values of Properties of Hydrocarbons and Related Compounds," Thermodynamic Research Center, Texas A&M University, College Station, Tex., April 30, 1969.
(3) American Society for Information Science, National Auxiliary Publications Service, c/o CCM Information Sciences, Inc., 909 Third Ave., New York, N. Y., 10022.
(4) Burlew, J. S., *J. Amer. Chem. Soc.*, **62**, 696 (1940).
(5) Canjar, L. N., Manning, F. S., "Thermodynamic Properties and Reduced Correlations for Gases," Gulf Publishing Co., Houston, Tex., 1967, pp 113–18.
(6) Connolly, J. F., Kandalic, G. A., *J. Chem. Eng. Data*, **7**, 137 (1962).
(7) Das, T. R., Kuloor, N. R., *Indian J. Technol.*, **5** (2), 51 (1967).
(8) Gilliland, E. R., Lukes, R. V., Scheeline, H. W., *Am. Inst. Mining Met. Engr.*, **132**, 132 (1939).
(9) Gottschal, A. J., Korvezee, A. E., *Rec. Trav. Chim.*, **72**, 931 (1956).
(10) Kay, W. B., Hissong, D., "The Critical Properties of Hydrocarbons; Simple Mixtures," *Proc. Amer. Petrol. Inst. Refining Div.*, **47**, 653 (1967).
(11) Kemp, H. S., unpublished doctoral dissertation, University of Michigan, July 1944.
(12) Lenoir, J. M., Robinson, D. R., Hipkin, H. G., *J. Chem. Eng. Data*, **15**, 23 (1970); **15**, 26 (1970).
(13) Lindsay, J. D., Brown, G. G., *Ind. Eng. Chem.*, **27**, 817 (1935).
(14) Lundberg, G. W., *J. Chem. Eng. Data*, **9**, 193 (1964).
(15) Meyer, C. A., McClintock, R. B., Silvestri, G. J., Spencer, R. C., "Thermodynamic and Transport Properties of Steam," *Am. Soc. Mech. Engrs.*, New York, 1967.
(16) Organick, E. I., Studhalter, W. R., *Chem. Eng. Progr.*, **44**, 847 (1948).
(17) Osborne, N. S., Ginnings, D. C., *J. Res. Natl. Bur. Standards*, **39**, 453 (1937).
(18) Riediger, B., *Chem. Ing. Tech.*, **23**, 272 (1951).

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Enthalpies of Mixtures of Benzene and Cyclohexane

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Measured enthalpy values are reported on the −200° F basis for mixtures of 80.0, 59.5, 31.7, and 19.9 wt % benzene in cyclohexane. The results are shown from 460° to 590° F with pressures from 0 to 1400 psia.

Enthalpy measurements have been made on four mixtures of benzene and cyclohexane, a close-boiling nonideal system that exhibits a minimum critical temperature at about 22 wt % benzene (*6*). The measurements were obtained with a flow calorimeter that operates isobarically and obtains enthalpy differences relative to 75° F and the liquid phase at the pressure of measurement. This calorimeter has previously been described with its constructional and operational characteristics (*9*). Over a three-year operating period, the calorimeter has been shown to measure enthalpies with an average deviation of 1.5 Btu/lb, established by making measurements at periodic intervals with liquid water and *n*-pentane, and comparing the results with literature values (*2, 12*). These measurements on water and pentane were made during the study of the benzene–cyclohexane systems, assuring the maintenance of the established accuracy of measurement.

The benzene used had a density at 75° F of 0.8730 gram/cc, with refractive index n_D^{20} = 1.50030. It was obtained from the Phillips Petroleum Co., with stated purity exceeding 99.0%. The cyclohexane was also received from the Phillips Petroleum Co. with purity of 99.5%, a density at 75° F of 0.7749 gram/cc, and a refractive index of 1.42604. The American Petroleum Institute data book shows values of density of 0.8749 gram/cc with n_D^{20} = 1.50112 for benzene, and 0.7750 gram/cc, and refractive index of 1.4262 for cyclohexane. The mixtures were prepared by weighing pure benzene and cyclohexane for a sample of 5000 grams. The precision of weighing was 2.5 grams, representing an uncertainty in the mixture composition due to weighing of less than 0.1%. While the calorimeter was operating, refractive index measurements were made of the mixtures to ensure that the composition remained constant.

A total of 651 measurements were made of enthalpies relative to 75° F and the pressure of measurement. These measurements have been tabulated and deposited with ASIS (*3*). The measured enthalpies have also been converted to a zero enthalpy basis of −200° F and the saturated liquid condition of the pure components to conform to the American Petroleum Institute data book basis (*1*). The enthalpy

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