termines whether $|E| < 0.001$. If $|E|$ is not less than 0.001, R is set equal to R' and the calculations of Equations 7, 8, 9, and 10 are repeated until $|E| < 0.001$.

Once $|E| < 0.001$, the calculation proceeds to Equations 11 and 12:

$$L_i = M_i R/(K_i + R) \quad (11)$$

$$V_i = M_i - L_i \quad (12)$$

The mole fractions of components in the feed and the liquid and vapor phases are evaluated as follows:

$$n_i = M_i / \sum_{i=1}^{n} M_i \quad (13)$$

$$X_i = L_i / \sum_{i=1}^{n} L_i \quad (14)$$

$$Y_i = V_i / \sum_{i=1}^{n} V_i \quad (15)$$

$$\sum_{i=1}^{n} n_i = \sum_{i=1}^{n} X_i = \sum_{i=1}^{n} Y_i = 1 \quad (16)$$

The program

The Fortran program developed for the flash calculations is named FLASH and can be run on IBM or IBM compatible personal computers with the MS DOS operating system. The program is based on the vapor-liquid equilibrium relationships given in handbooks available from the Gas Processors Suppliers Association, Tulsa, and other literature.

The program will handle flash calculations with feed streams containing up to 15 components. As an added feature, the calculation will check the feed composition at flash conditions for dew point and bubble point (i.e., whether the feed is either all vapor or all liquid).

These checks are performed before the flash calculations are started. If the feed is above the dew point or below the bubble point, an appropriate message is displayed on the screen. A default value for R (L/V ratio) = 1 is incorporated in the program to start the iterative process. Report-quality outputs are generated by the program, and the program can be operated either from a floppy diskette or it can be loaded onto a hard disk.

To operate the program, simply log onto the appropriate drive and type "FLASH.EXE" or "FLASH". If printed results are required, simply press the PrtSc key on the keyboard.

The program is not applicable to an adiabatic flash process when the feed stream is at a higher pressure than the flash pressure, and the heat for vaporization is provided by the enthalpy of the feed. In this situation, the flash temperature will be unknown and must be obtained by trial and error.

A temperature must be found at which both the material and energy balances are satisfied.

Examples

Four examples demonstrate the use of the program and the results computed by it.

Table 4

Gas liquefaction (Example 2)

Feed stream data

Component Number	Component Name	Feed, mole fraction	Equilibrium constant, K
1	CO_2	0.0112	0.90
2	CH_4	0.8957	2.70
3	C_2H_6	0.0526	0.38
4	C_3H_8	0.0197	0.098
5	iC_4H_{10}	0.0068	0.038
6	nC_4H_{10}	0.0047	0.024
7	C_5H_{12}	0.0038	0.0075
8	nC_6H_{14}	0.0031	0.0019
9	nC_7H_{16} and heavier	0.0024	0.0007

Input

```
Input flash temperature, °F.?                          20
Input flash pressure, psia?                            600
Input number of components?                            9
Input feed and equilibrium K of each component? 11.2   0.90
                                                895.7  2.70
                                                52.6   0.38
                                                19.7   0.098
                                                6.8    0.038
                                                4.7    0.024
                                                3.8    0.0075
                                                3.1    0.0019
                                                2.4    0.0007
```

Output

Multicomponent equilibrium flash calculation at 20.0° F. and 600.0 psi

Component number	K-value	Feed		Liquid		Vapor	
		Moles/hr	Mole frac.	Moles/hr	Mole frac.	Moles/hr	Mole frac.
1	0.900	11.200	0.011	0.506	0.012	10.694	0.011
2	2.700	895.700	0.896	13.903	0.340	881.797	0.919
3	0.380	52.600	0.053	5.299	0.130	47.301	0.049
4	0.098	19.700	0.020	5.966	0.146	13.734	0.014
5	0.038	6.800	0.007	3.593	0.088	3.207	0.003
6	0.024	4.700	0.005	3.006	0.074	1.694	0.002
7	0.007	3.800	0.004	3.231	0.079	0.569	0.001
8	0.002	3.100	0.003	2.968	0.073	0.132	0.000
9	0.001	2.400	0.002	2.361	0.058	0.039	0.000
Totals		**1,000.000**	**1.000**	**40.831**	**1.000**	**959.169**	**1.000**

Do you want to terminate the program? Yes/No

The first example is a 9-component still product accumulator stream that is compressed to 370 psia and cooled to 90° F.[4] The program is used to determine the amount of liquid and vapor produced at these conditions. Feed stream data and the program's results are shown in Table 3.

The second example flashes a feed stream to a natural gas liquefaction plant. The feed is flashed at 600 psia and 20° F.[3] The program determines the flow rates of the liquid and vapor streams at a feed flowrate of 1,000 moles/hr.

Feed stream data and the program's results are shown in Table 4.

A 12-component mixture is flashed at 860 psia and −65° F. for the third example.[1] Feed stream data and results are shown in Table 5.

Finally, the fourth example determines the equilibrium separation of a 5-component mixture at equilibrium conditions of 100 psia and 160° F.[10] Table 6 gives the feed stream data and results.

Editor's note: OGJ subscribers may obtain a free copy of the complete operating program on diskette by sending a blank, 5¼ in. floppy diskette, formatted to MS DOS, and a self-addressed, postage-paid or stamped return diskette mailer to: Refining/Petrochemical Editor, Oil & Gas Journal, P.O. Box 1941, Houston, TX, U.S.A., 77251.

Subscribers outside of the U.S. send the diskette and return mailer without return postage to the same address. This offer will expire Mar. 31, *1991.*

Acknowledgment

The author thanks Dr. C. J. Mumford, senior lecturer, Aston University, U.K., for the review of this work, and the management of H&G Engi-