that the feed pool resid content is computed elsewhere by recursion of pooling streams and treats resid content as a property of the feed.

DATA FOR DELTA-BASED MODELS

The data used in the delta-based model must be developed by the user to reflect the parameters and their effect on the process yield. In the context of the refinery streams, only streams properties that are generally measured can be considered. For example, the cat reformer yield can be related to the naphthene plus aromatic content of the feed if the refinery has reference data to correlate the cat reformer yield at a given severity vs. (naphthene plus aromatic) content of the feed.

Care has to be taken that the shift vectors do not extrapolate data beyond the range for which these were developed. Also, as the shift vectors can take either positive or negative values, these should be declared free in the BOUND section of the LP model.

ATMOSPHERIC CRUDE DISTILLATION AND VDU MODELING

LP models for crude and vacuum distillation can be constructed exactly in the same manner as done in the case of other process unit submodels. Most refineries may have more than one crude unit and may be processing more than one crude oil. Also, a crude unit may operate in more than one mode; for example, one crude unit mode may maximize the production of naphtha and another may maximize the production of kerosene. It is, therefore, convenient to enter all data on yields and properties of the various cuts from different crude oils and crude and vacuum distillation units present and their utility consumption, pooling of various cuts from crude and vacuum units in three tables for easy updating.

ASSAYS TABLE

Data in the form of yields of various crude on different CDUs and properties of cut produced is entered in a single table, the Assay Table (Table 13-17). This table does not directly generate any matrix but only provides data for crude and vacuum units modeling. The yields in the Assay Table could be either in volume or weight units. The column names in the table are three character operation modes[5] of various crude columns. There are four type of rows in this table.

The first set of rows is used to provide cut yields. The row names are VBALxxx, WBALxxx, or DBAL.xxx. VBAL and WBAL indicate a volume or weight basis yield. The tag xxx is the name of the cut produced from the distillation. The DBAL row defines a cut being produced not on the crude distillation unit but from a downstream unit. Examples of such cuts in the refinery are numerous. For example, a crude distillation column may produce a broad cut containing naphtha and some kerosene. This cut is further fractionated into naphtha and kerosene in a downstream naphtha fractionation column. In this case, as naphtha is not being actually produced on the crude column but somewhere else, it will be represented in the Assay Table by the DBAL row instead of the VBAL row.

The second set of rows may be used to specify atmospheric or vacuum unit utility consumption that is crude specific. The row name for this set is in the form of UATMxxx or UVACxxx, where xxx is the utility consumed.

A third set of rows may be used to specify atmospheric or vacuum unit capacity consumption values that are crude specific. The row name for this set is CCAPATM or CCAPVAC, and the entries for each crude are the units of capacity consumed per unit charged to the atmospheric and vacuum towers.

The fourth set of rows is used to provide cut properties. The row names for this set are Ipppxxx where ppp is the property (SPG, SUL, API, etc.) and xxx is the cut name. The first letter, I, indicates that this is property data. The second through fourth characters of the row name identify the property, while the final three characters identify the process stream to which this property applies:

ISPGLN1	Specific gravity of LN1.
ISULW26	Sulfur content of cut W26.
IVBIL26	Viscosity blend index of cut L26.

The coefficients in the I rows are the values of the specific property of a specified stream. I rows do not themselves appear in the matrix. The LP model uses this data by multiplying, for example, ISPGLN1, with volumes in row VBALLN1 and placing the result in recursion row RSPGLN1 for computing the specific gravity of a blend of streams.

Table 13-17
Crude Assays

*	MODE	1CDU A1N	1CDU A1K	2CDU A2N	2CDU A2K	3CDU A3N	3CDU A3K	4CDU A4N	4CDU A4K	5CDU A5N	5CDU A5K	1CDU B1N	1CDU B1K	2CDU B2N	2CDU B2K	3CDU B3N	3CDU B3K	4CDU B4N	4CDU B4K	5CDU B5N	5CDU B5K
*	Atmos Unit Yields																				
VBALGA1	CDU Off Gas (C3 -)	0.0051	0.0051	0.0049	0.0049	0.0049	0.0049	0.0056	0.0056	0.0051	0.0051	0.0071	0.0071	0.0060	0.0060	0.0060	0.0060	0.0106	0.0106	0.0060	0.0060
VBALC41	CDU C3/C4	0.0194	0.0194	0.0205	0.0205	0.0205	0.0205	0.0148	0.0148	0.0194	0.0194	0.0129	0.0129	0.0151	0.0151	0.0151	0.0151	0.0065	0.0065	0.0151	0.0151
VBALLS1	CDU LSRs	0.0744	0.0744	0.0694	0.0694	0.0616	0.0616	0.1063	0.1063	0.0714	0.0714	0.0494	0.0494	0.0445	0.0445	0.0381	0.0381	0.0791	0.0791	0.0465	0.0465
VBALMN4	4A MSR							0.0874	0.0585									0.0843	0.0625		
VBALHN1	CDU HSR	0.0984	0.0765	0.0894	0.0565	0.1032	0.0873	0.1114		0.0964	0.0745	0.1001	0.0774	0.0912	0.0586	0.1026	0.0878	0.1192		0.0952	0.0734
VBALHA4	CDU Arab HSR for KRU								0.1402												
VBALHB4	CDU Bah HSR for KRU																		0.1409		
VBALKN1	CDU Kerosene	0.1651		0.1999		0.1730		0.0626	0.0626	0.1601		0.1664		0.2010		0.1802		0.0677	0.0677	0.1693	
VBALKA1	CDU Arab Ker for KRU		0.1870		0.2327		0.1889				0.1820										
VBALKB1	CDU Bah Ker for KRU												0.1891		0.2336		0.1950				0.1911
VBALDN1	CDU Light Dsl	0.1153	0.1153	0.1004	0.1004	0.2138	0.2138	0.0726	0.0726	0.1323	0.1323	0.1310	0.1310	0.1162	0.1162	0.2343	0.2343	0.0789	0.0789	0.1419	0.1419
VBALMI4	4A CDU Med/Int Dsl							0.1243	0.1243									0.1389	0.1389		
VBALRA1	Atmos Resid	0.5224	0.5224	0.5154	0.5154					0.5154	0.5154	0.5330	0.5330	0.5261	0.5261					0.5261	0.5261
VBALHD3	Heavy Diesels					0.0129	0.0129	0.1263	0.1263							0.0138	0.0138	0.1370	0.1370		
VBALVA3	CDU Vac Resids					0.4100	0.4100	0.2887	0.2887							0.4099	0.4099	0.2779	0.2779		
*		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
*	Total Yield																				
CCAPATM	CDU CAPACITY	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CCAPVAC	VDU CAPACITY					1	1	1	1							1	1	1	1		
UATMFUL	GAS MSCF/BBL CRUDE	0.1613	0.1613	0.1613	0.1613	0.1963	0.1963	0.1753	0.1753	0.1613	0.1613	0.1613	0.1613	0.1613	0.1613	0.1963	0.1963	0.1753	0.1753	0.1613	0.1613
*	DEFERRED CUT YIELDS (Vacuum units)																				
*	1 VDU Normal Mode																				
DBALW11	1VDU WGO ON CRUDE	0.0462	0.0462	0.0446	0.0446							0.0545	0.0545	0.0522	0.0522						
DBALL11	1VDU DGO ON CRUDE	0.2544	0.2544	0.2499	0.2499							0.2709	0.2709	0.2663	0.2663						
DBALV11	1VDU VR ON CRUDE	0.2218	0.2218	0.2208	0.2208							0.2076	0.2076	0.2075	0.2075						
*	1 VDU Asphalt Operation																				
DBALLW1	1VDU LWGO ON CRUDE											0.0011	0.0011	0.0011	0.0011						
DBALW21	1VDU WGO ON CRUDE											0.0374	0.0374	0.0370	0.0370						
DBALL21	1VDU DGO ON CRUDE											0.3295	0.3295	0.3232	0.3232						
DBALBS1	1VDU BSGO ON CRUDE											0.0245	0.0245	0.0242	0.0242						
DBALAS1	1VDU ASP ON CRUDE											0.1404	0.1404	0.1407	0.1407						
*	1 VDU BSGO PRODUCTION																				
DBALW31	1VDU WGO ON CRUDE	0.0322	0.0322	0.0312	0.0312																
DBALL31	1VDU DGO ON CRUDE	0.3113	0.3113	0.3051	0.3051																
DBALBS3	1VDU BSGO ON CRUDE	0.0199	0.0199	0.0191	0.0191																
DBALV31	1VDU VACRES ON CRUDE	0.1591	0.1591	0.1601	0.1601																

Table 13-17
Continued

*	MODE	1CDU A1N	1CDU A1K	2CDU A2N	2CDU A2K	3CDU A3N	3CDU A3K	4CDU A4N	4CDU A4K	5CDU A5N	5CDU A5K	1CDU B1N	1CDU B1K	2CDU B2N	2CDU B2K	3CDU B3N	3CDU B3K	4CDU B4N	4CDU B4K	5CDU B5N	5CDU B5K
*	check yield = AR yld	0.5224	0.5224	0.5154	0.5154																
DBALW15	5VDU WGO ON CRUDE	0.0031	0.0031	0.0031	0.0031	0.0033	0.0033			0.0031	0.0031	0.0032	0.0032	0.0032	0.0032	0.0000	0.0000			0.0032	0.0032
DBALL15	5VDU LVGO ON CRUDE	0.1328	0.1328	0.1269	0.1269	0.0277	0.0277			0.1269	0.1269	0.1476	0.1476	0.1420	0.1420	0.0407	0.0407			0.1420	0.1420
DBALH15	5VDU HVGO ON CRUDE	0.2226	0.2226	0.2207	0.2207	0.2085	0.2085	0.1055	0.1055	0.2207	0.2207	0.2327	0.2327	0.2307	0.2307	0.2126	0.2126	0.1078	0.1078	0.2307	0.2307
DBALV15	5VDU VR ON CRUDE	0.1638	0.1638	0.1647	0.1647	0.1705	0.1705	0.1833	0.1833	0.1647	0.1647	0.1495	0.1495	0.1502	0.1502	0.1566	0.1566	0.1701	0.1701	0.1502	0.1502
*	5 VDU Asphalt Operation																				
DBALW25	5VDU WGO ON CRUDE																			0.0032	0.0032
DBALL25	5VDU LVGO ON CRUDE																			0.1422	0.1422
DBALH25	5VDU HVGO ON CRUDE																			0.2416	0.2416
DBALAS5	5VDU ASP ON CRUDE																			0.1391	0.1391
*	6VDU AT 65 MBPD (SVD7)																				
DBALW26	6VDU WGO ON CRUDE	0.0021	0.0021	0.0026	0.0026					0.0026	0.0026	0.0021	0.0021	0.0026	0.0026					0.0026	0.0026
DBALL26	6VDU LVGO ON CRUDE	0.1281	0.1281	0.1212	0.1212	0.0232	0.0232			0.1212	0.1212	0.1427	0.1427	0.1351	0.1351	0.0279	0.0279			0.1351	0.1351
DBALH26	6VDU HVGO ON CRUDE	0.2221	0.2221	0.2207	0.2207	0.1987	0.1987	0.0838	0.0838	0.2207	0.2207	0.2337	0.2337	0.2338	0.2338	0.2116	0.2116	0.0900	0.0900	0.2338	0.2338
DBALV26	6VDU VR ON CRUDE	0.1701	0.1701	0.1709	0.1709	0.1881	0.1881	0.2049	0.2049	0.1709	0.1709	0.1544	0.1544	0.1545	0.1545	0.1704	0.1704	0.1879	0.1879	0.1545	0.1545
*	VAC YIELDS (VOLUME) AS PROPERTY OF ATM RESID (1, 2, 5 CDU)																				
*	1 VDU Normal Mode																				
IW11RA1	1VDU on Atm Res-WGO	0.0885	0.0885	0.0866	0.0866							0.1023	0.1023	0.0993	0.0993						
IL11RA1	1VDU on Atm Res-DGO	0.4869	0.4869	0.4849	0.4849							0.5083	0.5083	0.5063	0.5063						
IV11RA1	1VDU on Atm Res-VRes	0.4245	0.4245	0.4285	0.4285							0.3895	0.3895	0.3945	0.3945						
*	CHECK	1	1	1	1							1	1	1	1						
*	1 VDU Asphalt mode																				
ILW1RB1	1VDU LWGO ON RESID											0.0020	0.0020	0.0020	0.0020						
IW21RB1	1VDU WGO ON AT RESID											0.0703	0.0703	0.0703	0.0703						
IL21RB1	1VDU DGO ON ATRESID											0.6183	0.6183	0.6143	0.6143						
IBS1RB1	1VDU BSGO ON AT RES.											0.0460	0.0460	0.0460	0.0460						
IAS1RB1	1VDU ASP ON AT RESID											0.2635	0.2635	0.2675	0.2675						
*	CHECK											1	1	1	1						
*	1 VDU WITH BSGO PRODUCTION																				
IW31RA1	1VDU WGO ON AT RESID	0.0616	0.0616	0.0606	0.0606																
IL31RA1	1VDU LVGO ON ATRESID	0.5959	0.5959	0.5919	0.5919																
IBS3RA1	1VDU BSGO ON AT RES.	0.0380	0.0380	0.0370	0.0370																
IV31RA1	1VDU VRES ON AT RESID	0.3045	0.3045	0.3105	0.3105																
*	CHECK	1	1	1	1																
*	5VDU AT 33 MBPD																				
IW15RA1	5VDU WGO ON AT RESID	0.0060	0.0060	0.0060	0.0060					0.0060	0.0060	0.0060	0.0060	0.0060	0.0060						
IL15RA1	5VDU LVGO ON ATRESID	0.2542	0.2542	0.2462	0.2462					0.2462	0.2462	0.2770	0.2770	0.2700	0.2700						

IH15RA1	5VDU HVGO ON ATRESID	0.4262	0.4262	0.4282	0.4282					0.4282	0.4282	0.4365	0.4365	0.4385	0.4385						
IV15RA1	5VDU VR ON AT RESID	0.3136	0.3136	0.3196	0.3196					0.3196	0.3196	0.2805	0.2805	0.2855	0.2855						
*	CHECK	1	1	1	1					1	1	1	1	1	1						
*	5 VDU Asphalt Mode																				
IW25RB1	5VDU WGO ON AT RESID																			0.0060	0.0060
IL25RB1	5VDU LVGO ON ATRESID																			0.2703	0.2703
IH25RB1	5VDU HVGO ON ATRESID																			0.4593	0.4593
IAS5RB1	5VDU ASP ON AT RESID																			0.2645	0.2645
*	CHECK																			1	1
	VDU YIELDS (LV) AS PROPERTY OF ATM RESIDS EX CDU 1, 2 & 5																				
*	6 VDU AT 50 MBPD																				
IW16RA1	6VDU WGO ON ATRESID	0.0040	0.0040	0.0050	0.0050					0.005	0.005	0.005	0.005	0.006	0.006						
IL16RA1	6VDU LVGO ON ATRESID	0.2462	0.2462	0.2362	0.2362					0.236225	0.236225	0.267768	0.267768	0.256768	0.256768						
IH16RA1	6VDU HVGO ON ATRESID	0.4362	0.4362	0.4402	0.4402					0.440166	0.440166	0.449519	0.448519	0.455519	0.455519						
IV16RA1	6VDU VR ON AT RESID	0.3136	0.3136	0.3186	0.3186					0.318609	0.318609	0.278713	0.278713	0.281713	0.281713						
*	CHECK	1	1	1	1					1	1	1	1	1	1						
*																					
*	VAC YLD AS PROPERTY OF VAC RESID (3, 4 CDU)																				
*	5 VDU Normal mode																				
IW15VA3	5VDU WGO ON V. RESID					0.0080	0.0080									0	0				
IL15VA3	5VDU LVGO ON V.RESID					0.0675	0.0675									0.09926	0.09926				
IH15VA3	5VDU HVGO ON V.RESID					0.5086	0.5086	0.3653	0.3653							0.518779	0.518779	0.388033	0.388033		
IV15VA3	5VDU VR ON V. RESID					0.4158	0.4158	0.6347	0.6347							0.381962	0.381962	0.611967	0.611967		
*	Check					1	1	1	1							1	1	1	1		
*	6 VDU AT 65 MBPD																				
IW26VA3	6VDU WGO ON V. RESID																				
IL26VA3	6VDU LVGO ON V.RESID					0.0565	0.0565									0.068011	0.068011				
IH26VA3	6VDU HVGO ON V.RESID					0.4846	0.4846	0.2903	0.2903							0.516282	0.516282	0.32379	0.32379		
IV26VA3	6VDU VR ON V. RESID					0.4588	0.4588	0.7097	0.7097							0.415707	0.415707	0.67621	0.67621		
*	Check					1	1	1	1							1	1	1	1		
*	ATMOS CUT PROPERTIES																				
*	LS1 – CDU LSR											Properties in BLNGASO : RVP, 230, FPI, OLE, LSR									
ISPGLS1	LSR – Spec Grav	0.6563	0.6563	0.6666	0.6666	0.6663	0.6663	0.6762	0.6762	0.6695	0.6695	0.6674	0.6674	0.6639	0.6639	0.6626	0.6626	0.6795	0.6795	0.6662	0.6662
ISULLS1	LSR – Sulfur	0.018	0.018	0.017	0.017	0.016	0.016	0.018	0.018	0.017	0.017	0.003	0.003	0.002	0.002	0.003	0.003	0.005	0.005	0.003	0.003
I130LS1	LSR – %VAP @ 130	50.0	50.0	56.0	56.0	60.0	60.0	38.0	38.0	51.0	51.0	40.0	40.0	43.0	43.0	51.0	51.0	24.0	24.0	42.0	42.0
IRONLS1	LSR-RON	61.5	61.5	61.5	61.5	63.5	63.5	54.5	54.5	61.5	61.5	61.0	61.0	61.0	61.0	64.5	64.5	51.5	51.5	61.0	61.0
IR30LS1	LSR – RON 3CC	82.5	82.5	82.5	82.5	84.5	84.5	75.5	75.5	82.5	82.5	82.0	82.0	82.0	82.0	85.5	85.5	72.4	72.4	82.0	82.0
IMONLS1	LSR – MON	60.5	60.5	60.5	60.5	62.5	62.5	53.5	53.5	60.5	60.5	60.0	60.0	60.0	60.0	63.5	63.5	50.5	50.5	60.0	60.0
IM30LS1	LSR – MON 3CC	81.5	81.5	81.5	81.5	83.5	83.5	74.5	74.5	81.5	81.5	81.0	81.0	81.0	81.0	84.5	84.5	71.4	71.4	81.0	81.0
IVLPLS1	LSR – VLPT	47.0	47.0	46.0	46.0	46.0	46.0	47.0	47.0	48.0	48.0	48.0	48.0	47.0	47.0	47.0	47.0	51.0	51.0	48.0	48.0
ISPGMN4	MSR – Spec Grav							0.7502	0.7456									0.7453	0.7415		
ISULMN4	MSR – Sulfur							0.037	0.025									0.016	0.014		
IRVPMN4	MSR – RVP							4.9	4.9									4.2	4.2		
IFPIMN4	MSR – Freeze Index							9	9									9	9		
IN2AMN4	MSR – N+2A							39.6	36.4									47.3	43.0		

Table 13-17
Continued

	MODE	1CDU A1N	1CDU A1K	2CDU A2N	2CDU A2K	3CDU A3N	3CDU A3K	4CDU A4N	4CDU A4K	5CDU A5N	5CDU A5K	1CDU B1N	1CDU B1K	2CDU B2N	2CDU B2K	3CDU B3N	3CDU B3K	4CDU B4N	4CDU B4K	5CDU B5N	5CDU B5K
ISPGHN1	HSR – SG	0.7364	0.7322	0.7338	0.7300	0.7315	0.7284	0.7940		0.7348	0.7307	0.7331	0.7284	0.7302	0.7240	0.7282	0.7248	0.7936		0.7309	0.7263
ISULHN1	HSR – SUL	0.033	0.029	0.029	0.026	0.031	0.028	0.143		0.028	0.027	0.017	0.013	0.013	0.010	0.014	0.012	0.121		0.014	0.011
IRVPHN1	HSR – RVP	7.6	7.6	8.3	8.3	9.7	9.7	0.7		7.6	7.6	6.9	6.9	7.6	7.6	9.0	9.0	0.7		7.6	7.6
IN2AHN1	HSR – N + 2A	34.9	34.9	34.1	35.3	32.7	31.5	58.2		34.7	34.1	40.6	38.5	39.5	36.6	38.1	36.6	64.6		39.7	37.6
IDIIHN1	HSR – Diesel Index							66.4										66			
IPPIHN1	HSR – Pour Index							36										36			
I144HN1	HSR – 144 Index							−191										−191			
I154HN1	HSR – 154 Index							−175										−175			
IVBIHN1	HSR – H Value							−267										−282			
IFPIHN1	HSR – Freeze Index							32.3										28.9			
ISPGKN1	Kero – SG	0.7879	0.7865	0.7890	0.7893	0.7884	0.7873	0.8024	0.7880	0.7862	0.7855	0.7881	0.7865	0.7890	0.7892	0.7887	0.7874	0.7914	0.7894	0.7863	0.7857
ISULKN1	Kero – Sul	0.107		0.104		0.119		0.237	0.237	0.125		0.094		0.091		0.105		0.205	0.205	0.112	
IVBIKN1	Kero – H Value	−303		−291		−296		−222	−222	−310		−310		−303		−305		−233	−233	−315	
IFPIKN1	Kero – Freeze Index	33		34		34.1		75.7	75.7	29		29.6		30		29		65.5	65.5	26	
IPPIKN1	Kero – Pour Index	24	23	28	28	25	25	56	24	23	22	26	25	28	29	27	26	32	28	24	24
IDIIKN1	Kero – Diesel Index	67.1		67.2		67.2		63.2	63.2	67.6		66.4		66.4		66.4		61.8	61.8	66.9	
I144KN1	Kero – 144 Index	−196	−197	−195	−195	−196	−197	12	−196	−198	−198	−196	−197	−195	−195	−195	−196	−193	−195	−197	−198
I154KN1	Kero – 154 Index	−179	−181	−179	−178	−179	−180	8	−179	−181	−181	−179	−181	−179	−178	−179	−180	−177	−178	−181	−181
ISPGDN1	LDO – SG	0.8391	0.8391	0.8461	0.8461	0.8511	0.8511	0.8344	0.8344	0.8424	0.8424	0.8428	0.8428	0.8504	0.8504	0.8556	0.8556	0.8409	0.8409	0.8485	0.8485
ISULDN1	LDO – Sul	1.100	1.100	1.251	1.251	1.320	1.320	0.840	0.840	1.160	1.160	1.029	1.029	1.169	1.169	1.271	1.271	0.804	0.804	1.148	1.148
IPPIDN1	LDO – Pour Index	197	197	235	235	308	308	190	190	240	240	197	197	220	220	300	300	187	187	240	240
I144DN1	LDO – 144 Index	58	58	64	64	34	34	77	77	56	56	57	57	63	63	34	34	66	66	57	57
I154DN1	LDO – 154 Index	33	33	39	39	14	14	48	48	31	31	32	32	38	38	15	15	39	39	33	33
IDIIDN1	LDO – Diesel Index	57.9	57.9	56.6	56.6	57.1	57.1	57.4	57.4	57.2	57.2	55.3	55.3	53.7	53.7	52.5	52.5	54.5	54.5	54.2	54.2
IVBIDN1	LDO – H Value	−68	−68	−37	−37	−19	−19	−76	−76	−50	−50	−72	−72	−45	−45	−24	−24	−82	−82	−50	−50
ISPGMI4	M/ID – SG							0.8681	0.8681									0.8718	0.8718		
ISULMI4	M/ID – Sul							1.677	1.677									1.645	1.645		
IVBIMI4	M/ID – H Value							57	57									48	48		
IPPIMI4	M/ID – Pour Index							525	525									467	467		
IDIIMI4	M/ID – Diesel Index							51.5	51.5									49.2	49.2		
I144MI4	M/ID – 144 Index							67	67									62	62		
I154MI4	M/ID – 154 Index							42	42									39	39		
ISPGRA1	Atm Res – SG	0.9463	0.9463	0.9465	0.9465					0.9465	0.9465	0.9459	0.9459	0.9463	0.9463						
ISULRA1	Atm Res – Sul	3.14	3.14	3.17	3.17					3.17	3.17	3.38	3.38	3.41	3.41						
IVBIRA1	Atm Res – H Value	446.1	446.1	448.1	448.1					448.1	448.1	431.7	431.7	434.7	434.7						
ISPGHD3	HDO – SG					0.9058	0.9058	0.9113	0.9113							0.9088	0.9088	0.9144	0.9144		
ISULHD3	HDO – Sul					2.265	2.265	2.365	2.365							2.480	2.480	2.586	2.586		

IVBIHD3	HDO – H Value					244	244	271	271					234	234	261	261
IPPIHD3	HDO – Pour Index					1287	1287	1507	1507					1251	1251	1473	1473
I144HD3	HDO – 144 Index					58	58	57	57					57	57	55	55
I154HD3	HDO – 154 Index					38	38	37	37					37	37	36	36
ICONHD3	HDO – Con Carbon					0.04	0.04	0.07	0.07					0.04	0.04	0.07	0.07
ISPGVA3	Vac Res – SG					0.9672	0.9672	0.9965	0.9965					0.9697	0.9697	0.9993	0.9993
ISULVA3	Vac Res – Sul					3.522	3.522	4.030	4.030					3.835	3.835	4.389	4.389
IVBIVA3	Vac Res – H Value					542.0	542.0	661.2	661.2					540.0	540.0	670.7	670.7
ICONVA3	Vac Res – Con Carbon					8.93	8.93	13.4	13.4					10.63	10.63	15.3	15.3
I144VA3	Vac Res – 144 Index					39	39	31	31					38	38	29	29
I154VA3	Vac Res – 154 Index					25	25	20	20					24	24	19	19
IDIIVA3	Vac Res – Diesel Index					31.3	31.3	21.5	21.5					31.3	31.3	21.5	21.5
IPPIVA3	Vac Res – Pour Index					523.2	523.2	990.3	990.3					523.2	523.2	990.3	990.3
*	DEFERRED CUT PROPERTIES																
* 1VDU Normal mode																	
ISPGW11	1VDU WGO – SG	0.8554	0.8554	0.8536	0.8536					0.859	0.859	0.8568	0.8568				
ISULW11	1VDU WGO – Sul	1.408	1.408	1.373	1.373					1.369	1.369	1.332	1.332				
IPPIW11	1VDU WGO – Pour Ind	388	388	378	378					378	378	367	367				
IVBIW11	1VDU WGO – H Value	4	4	−4	−4					−4	−4	−12	−12				
IDIIW11	1VDU WGO – Diesel Ix	50.2	50.2	50.2	50.2					54.1	54.1	54.1	54.1				
ISPGL11	1VDU DGO – SG	0.9093	0.9093	0.9099	0.9099					0.9122	0.9122	0.9128	0.9128				
ISULL11	1VDU DGO – Sul	2.352	2.352	2.362	2.362					2.567	2.567	2.582	2.582				
IPPIL11	1VDU DGO – Pour Ind	1541	1541	1562	1562					1610	1610	1641	1641				
IVBIL11	1VDU DGO – H Value	261	261	264	264					252	252	255	255				
ISPGV11	1VDU VR – SG	1.0076	1.0076	1.0076	1.0076					1.0165	1.0165	1.0165	1.0165				
ISULV11	1VDU VR – Sul	4.029	4.029	4.029	4.029					4.640	4.640	4.639	4.639				
IVBIV11	1VDU VR – H Value	712	712	712	712					748	748	748	748				
ICONV11	1VDU VR – Con Carbon	16.6	16.6	16.6	16.6					20.1	20.1	20.1	20.1				
I144V11	1VDU VR – 144 Index	26	26	26	26					22	22	22	22				
I154V11	1VDU VR – 154 Index	17	17	17	17					15	15	15	15				
*																	
* 1VDU Asphalt Mode																	
ISPGW21	1VDU WGO – SG									0.8585	0.8585	0.846	0.846				
ISULW21	1VDU WGO – Sul									1.171	1.171	1.134	1.134				
IPPIW21	1VDU WGO – Pour Ind									277	277	268	268				
IVBIW21	1VDU WGO – H Value									−29	−29	−29	−29				
IDIIW21	1VDU WGO – Diesel Ind									54.1	54.1	54.7	54.7				
ISPGL21	1VDU DGO – SG									0.9174	0.9174	0.9183	0.9183				
ISULL21	1VDU DGO – Sul									2.691	2.691	2.712	2.712				
IPPIL21	1VDU DGO – Pour Ind									1941	1941	1972	1972				
IVBIL21	1VDU DGO – H Value									280	280	284	284				
1 VDU bsgo mode																	
ISPGW31	1VDU WGO – SG	0.8435	0.8435	0.843	0.843												
ISULW31	1VDU WGO – Sul	1.196	1.196	1.189	1.189												
IPPIW31	1VDU WGO – Pour Ind	260	260	276	276												
IVBIW31	1VDU WGO – H Value	−46	−46	−47	−47												
IDIIW31	1VDU WGO – Diesel Ind	54.1	54.1	54.7	54.7												
ISPGL31	1VDU DGO – SG	0.9149	0.9149	0.9156	0.9156					0.9149	0.9149	0.9156	0.9156				
ISULL31	1VDU DGO – Sul	2.46	2.46	2.471	2.471					2.46	2.46	2.471	2.471				

Table 13-17
Continued

*	MODE	1CDU A1N	1CDU A1K	2CDU A2N	2CDU A2K	3CDU A3N	3CDU A3K	4CDU A4N	4CDU A4K	5CDU A5N	5CDU A5K	1CDU B1N	1CDU B1K	2CDU B2N	2CDU B2K	3CDU B3N	3CDU B3K	4CDU B4N	4CDU B4K	5CDU B5N	5CDU B5K
IPPIL31	1VDU DGO – Pour Ind	1872	1872	1893	1893							1872	1872	1893	1893						
IVBIL31	1VDU DGO – H Value	289	289	292	292							289	289	292	292						
ISPGV31	1VDU VR – SG	1.0220	1.0220	1.0217	1.0217																
ISULV31	1VDU VR – Sul	4.249	4.249	4.245	4.245																
IVBIV31	1VDU VR – H Value	774	774	772	772																
ICONV31	1VDU VR – Con Carbon	21.5	21.5	21.4	21.4																
I144V31		0.22																			
I154V31		0.15																			
* 5 VDU Normal mode																					
ISPGW15	5VDU WGO – SG	0.8155	0.8155	0.8164	0.8164	0.8045	0.8045			0.8164	0.8164	0.8112	0.8112	0.8112	0.8112					0.8112	0.8112
ISULW15	5VDU WGO – Sul	0.460	0.460	0.530	0.530	0.259	0.259			0.530	0.530	0.385	0.385	0.385	0.385					0.385	0.385
IPPIW15	5VDU WGO – Pour Ind	61	61	61	61	93	93			61	61	56	56	56	56					56	56
IVBIW15	5VDU WGO – H Value	185	185	220	220	180	180			220	220	−200	−200	−200	−200					−200	−200
IDIIW15	5VDU WGO – Diesel Ind	62.5	62.5	62.6	62.6	62.1	62.1			64.4	64.4	60.8	60.8	61.3	61.3					64.2	64.2
I144W15	5VDU WGO – 144 Index	50	50	−101	−101	25	25			−101	−101	49	49	43	43					15	15
I154W15	5VDU WGO – 154 Index	24	24	−99	−99	4	4			−99	−99	23	23	18	18					−5	−5
ISPGL15	5VDU LVGO – SG	0.8716	0.8716	0.8703	0.8703	0.8854	0.8854			0.8703	0.8703	0.8756	0.8756	0.8742	0.8742	0.8856	0.8856			0.8742	0.8742
ISULL15	5VDU LVGO – Sul	1.932	1.932	1.910	1.910	2.158	2.158			1.910	1.910	1.939	1.939	1.916	1.916	2.161	2.161			1.916	1.916
IPPIL15	5VDU LVGO – Pour Index	560	560	560	560	779	779			560	560	540	540	525	525	722	722			525	525
IVBIL15	5VDU LVGO – H Value	78	78	72	72	145	145			72	72	67	67	63	63	128	128			63	63
IDIIL15	5VDU LVGO – Dsl Indx	51.2	51.2	51.5	51.5	48.4	48.4			51.5	51.5	48.4	48.4	48.7	48.7	44.8	44.8			48.7	48.7
I144L15	5VDU LVGO – 144	63.5	63.5	61.1	61.1	57.9	57.9			61	61	62.2	62.2	62.1	62.1	57.6	57.6			60	60
I154L15	5VDU LVGO – 154	39.7	39.7	37.6	37.6	36	36			38	38	38.9	38.9	38.7	38.7	35.8	35.8			37	37
*	DEFERRED CUT PROPERTIES																				
ISPGH15	5VDU HVGO – SG	0.9386	0.9386	0.9388	0.9388	0.9432	0.9432	0.9503	0.9503	0.9388	0.9388	0.9416	0.9416	0.9416	0.9416	0.9425	0.9425	0.9505	0.9505	0.9416	0.9416
ISULH15	5VDU HVGO – Sul	2.864	2.864	2.866	2.866	2.87	2.87	3.061	3.061	2.866	2.866	3.241	3.241	3.24	3.24	3.26	3.26	3.57	3.57	3.24	3.24
IPPIH15	5VDU HVGO – Pour Ind	2800	2800	2800	2800	2800	2800	3100	3100	2800	2800	3100	3100	3100	3100	3100	3100	3500	3500	3100	3100
IVBIH15	5VDU HVGO – H Value	401	401	402	402	404	404	439	439	402	402	400	400	400	400	404	404	446	446	400	400
I144H15	5VDU HVGO – 144	48	48	48	48	46	46	44	44	48	48	47	47	47	47	46	46	44	44	47	47
I154H15	5VDU HVGO – 154	31	31	31	31	30	30	29	29	31	31	30	30	30	30	30	30	29	29	30	30
ISPGV15	5VDU VR – SG	1.0252	1.0252	1.0249	1.0249	1.0208	1.0208	1.0201	1.0201	1.0249	1.0249	1.0402	1.0402	1.0372	1.0372	1.0298	1.0298	1.0275	1.0275	1.0372	1.0372
ISULV15	5VDU VR – Sul	4.49	4.49	4.49	4.49	4.48	4.48	4.39	4.39	4.49	4.49	4.91	4.91	4.91	4.91	4.88	4.88	4.86	4.86	4.91	4.91
IVBIV15	5VDU VR – VBI	782.0	782.0	781.0	781.0	776.0	776.0	770.0	770.0	781.0	781.0	814.0	814.0	813.0	813.0	804.0	804.0	800.0	800.0	813.0	813.0
ICONV15	5VDU VR – Con Carbon	21.9	21.9	21.5	21.5	21.2	21.2	20.2	20.2	21.5	21.5	26.4	26.4	26	26	25.3	25.3	23.9	23.9	26	26
I144V15	5VDU VR – 144 Index	23	23	23	23	24	24	24	24	23	23	18	18	18	18	21	21	21	21	18	18
I154V15	5VDU VR – 154 Index	15	15	15	15	16	16	16	16	15	15	11	11	12	12	13	13	14	14	12	12

6 VDU 65 mbpd

ISPGW26	6VDU (65) WGO - SG	0.82	0.82	0.8158	0.8158					0.8158	0.8158	0.8188	0.8188	0.8134	0.8134					0.8134	0.8134
ISULW26	6VDU (65) WGO - Sul	0.664	0.664	0.58	0.58					0.58	0.58	0.543	0.543	0.458	0.458					0.458	0.458
IPPIW26	6VDU (65) WGO - PI	92	92	79	79					79	79	81	81	68	68					68	68
IVBIW26	6VDU (65) WGO - H	-144	-144	-164	-164					-164	-164	-167	-167	-190	-190					-190	-190
IDIIW26	6VDU (65) WGO - DI	60.7	60.7	61.4	61.4					61.4	61.4	59.5	59.5	60.5	60.5					60.5	60.5
I144W26	6VDU (65) WGO - 144	-329	-329	-336	-336					-336	-336	-331	-331	-340	-340					-340	-340
I154W26	6VDU (65) WGO - 154	-286	-286	-292	-292					-292	-292	-288	-288	-296	-296					-296	-296
ISPGL26	6VDU (65) LVGO - SG	0.8705	0.8705	0.8703	0.8703	0.8822	0.8822			0.8703	0.8703	0.874	0.874	0.8737	0.8737	0.8861	0.8861			0.8737	0.8737
ISULL26	6VDU (65) LVGO - Sul	1.91	1.91	1.907	1.907	2.113	2.113			1.907	1.907	1.907	1.907	1.906	1.906	2.154	2.154			1.906	1.906
IPPIL26	6VDU (65) LVGO - PI	547	547	551	551	682	682			551	551	522	522	525	525	654	654			525	525
IVBIL26	6VDU (65) LVGO - H	72	72	72	72	127	127			72	72	61	61	61	61	117	117			61	61
IDIIL26	6VDU (65) LVGO - DI	51.4	51.4	51.5	51.5	48.9	48.9			51.5	51.5	48.7	48.7	48.8	48.8	46	46			48.8	48.8
I144L26	6VDU (65) LVGO - 144	63	63	62	62	65	65			62	62	61	61	60	60	63	63			60	60
I154L26	6VDU (65) LVGO - 154	39	39	39	39	41	41			39	39	38	38	37	37	41	41			37	37
ISPGH26	6VDU (65) HVGO - SG	0.9348	0.9348	0.9348	0.9348	0.933	0.933	0.9476	0.9476	0.9348	0.9348	0.9379	0.9379	0.9379	0.9379	0.9362	0.9362	0.9509	0.9509	0.9379	0.9379
ISULH26	6VDU (65) HVGO - Sul	2.795	2.795	2.795	2.795	2.757	2.757	3.009	3.009	2.795	2.795	3.159	3.159	3.163	3.163	3.119	3.119	3.440	3.440	3.163	3.163
IPPIH26	6VDU (65) HVGO - PI	2609	2609	2609	2609	2477	2477	3065	3065	2609	2609	2856	2856	2856	2856	2676	2676	3379	3379	2856	2856
IVBIH26	6VDU (65) HVGO - H	385	385	385	385	375	375	441	441	385	385	383	383	383	383	374	374	443	443	383	383
I144H26	6VDU (65) HVGO - 144	49	49	49	49	50	50	45	45	49	49	48	48	48	48	48	48	44	44	48	48
I154H26	6VDU (65) HVGO - 154	32	32	32	32	32	32	29	29	32	32	31	31	31	31	31	31	29	29	31	31
ISPGV26	6VDU (65) VR - SG	1.0254	1.0254	1.0252	1.0252	1.0210	1.0210	1.0173	1.0173	1.0252	1.0252	1.0326	1.0326	1.0325	1.0325	1.0279	1.0279	1.0232	1.0232	1.0325	1.0325
ISULV26	6VDU (65) VR - Sul	4.5	4.5	4.5	4.5	4.4	4.4	4.4	4.4	4.5	4.5	4.5	4.5	4.5	4.5	4.8	4.8	4.8	4.8	4.9	4.9
IVBIV26	6VDU (65) VR - H	782.0	782.0	781.0	781.0	764.0	764.0	748.0	748.0	781.0	781.0	816.0	816.0	816.0	816.0	795.0	795.0	774.0	774.0	816.0	816.0
ICONV26	6VDU (65) VR -Carbon	21.2	21.2	21.1	21.1	19.5	19.5	18.2	18.2	21.1	21.1	26	26	26	26	24	24	22.2	22.2	26	26
I144V26	6VDU (65) VR - 144	23	23	23	23	24	24	25	25	23	23	20	20	20	20	21	21	22	22	20	20
I154V26	6VDU (65) VR - 154	15	15	15	15	16	16	16	16	15	15	13	13	13	13	14	14	15	15	13	13

The fifth set of rows is used to represent CDUs capacities. There are some other rows in this set, starting with E, L, or G, showing that it is equal to, less than, or greater to that row. These are control rows. The row names in this set are seven characters long and span all crude unit submodels.

CRDDISTL TABLE

This table is used by the model to define the structure of a number of theoretical or logical crude distillation submodels. Each logical crude unit may be considered one of many modes of operation of a crude unit. This table provides mapping between the Assays Table data and these logical crude units. Table 13-18 is an example of this table. The column names are three character tags for various operation modes of a crude units. Where individual crudes are being segregated, it may be convenient to use crude tags as logical unit tags, but this is not a requirement.

The rows of this table are divided into four sets. The first set comprises row names ATMTWR and VACTWR. The entries in these rows are integer values indicating which physical crude distillation towers are used by various logical crude units.

The second set of rows are ESTxxx, where xxx is the crude tag. The entries in these rows define the estimated charge of each crude to each logical crude unit. These estimates need not be accurate. The charge estimates are either on a weight or volume basis, depending on how crude assay data are entered. Thus, if the crude assay data are on a volume basis, entries in this table should be in volume units. The LP model uses these data to calculate the properties of straight-run cuts from a predefined mix of crude.

The next set of rows in this table are named ATMuuu and VACuuu and these define the consumption of utilities (fuel, steam, electricity, cooling water etc) in atmospheric and vacuum units for each of logical crude units.

CRDCUTS TABLE

The CRDCUTS Table defines the crude distillation cutting scheme used in the model. The row names are the three-character stream tags of the straight-run distillation cuts (see Table 13-19).

The column TYPE is used to identify the type of cut, and each cut must be allocated one of the following numbers:

> Generally the vendor supplied LP packages have an in-built mechanism to generate an Atmospheric Distillation Unit sub model

Table 13-18
CRDDISTL Table

TABLE CRDDISTL	TEXT	LC1	LC2	LC3	LC4	LC5
	REFINERY CONFIGURATION					
ATMTWR	PHYSICAL CDU	1	2	3	4	5
VACTWR	PHYSICAL VDU			3	4	
	CRUDE TO UNIT ESTIMATE					
ESTA1N	Chg AB 1CDU Normal	1.000				
ESTA1K	Chg AB 1CDU Kero	1.000				
ESTB1N	Chg Bah 1CDU Normal	1.000				
ESTB1K	Chg Bah 1CDU Kero	17.000				
ESTA2N	Chg AB 2CDU Normal		1.000			
ESTA2K	Chg AB 2CDU Kero		1.000			
ESTB2N	Chg Bah 2CDU Normal		1.000			
ESTB2K	Chg Bah 2CDU Kero		17.000			
ESTA3N	Chg AB 3CDU Normal			61.000		
ESTA3K	Chg AB 3CDU Kero			1.000		
ESTB3N	Chg Bah 3CDU Normal			1.000		
ESTB3K	Chg Bah 3CDU Kero			1.000		
ESTA4N	Chg AB 4CDU Normal				100.000	
ESTA4K	Chg AB 4CDU Kero				1.000	
ESTB4N	Chg Bah 4CDU Normal				1.000	
ESTB4K	Chg Bah 4CDU Kero				1.000	
ESTA5N	Chg AB 5CDU Normal					28.000
ESTA5K	Chg AB 5CDU Kero					2.000
ESTB5N	Chg Bah 5CDU Normal					28.000
ESTB5K	Chg Bah 5CDU Kero					2.000
	TOTAL CRUDE EST					
	265.000	20.000	20.000	64.000	103.000	58.000
	UTILITY CONSUMPTIONS (MSCF NATURAL GAS)					
ATMFUL	FUL ATM TOWER	0.1683	0.1683	0.2049	0.1829	0.1683

NOTE: THIS TABLE DEFINES THE ATMOS/VACUUM LOGIC. ONLY INTEGRAL CRUDE/VACUUM UNITS NEED BE NOTED HERE (I.E., 3 AND 4).

using data supplied by user in tables Assay, CRDDISTL, and CRDCUTS. The type of cut naming convention used in the LP package must be used. The cut type or number used here (0, 1, 2, 3, 9) are as per PIMS LP Package.

Table 13-19
CRDCUTS Table

TABLE CRDCUTS	TEXT	TYPE	LC1	LC2	LC3	LC4	LC5*
GA1	OFF GASES (C3 MINUS)	1	1	1	1	1	1
C41	CDU C3/C4	1	1	1	1	1	1
LS1	CDU LSR	1	1	1	1	1	1
MN4	4A MSR Pool	1				4	
HN1	HSR 39.5 C FLASH	1	1	2	3	4	5
HA4	HSR for KRU (Arab)	1				4	
HB4	HSR for KRU (Bah)	1				4	
KN1	KERO 39.5C FLASH	1	1	2	3	4	5
KA1	Kero for KRU (Arab)	1	1	2	3		5
KB1	Kero for KRU (Bah)	1	1	2	3		5
DN1	CDU LIGHT DIESEL	1	1	1	1	4	1
MI4	M + I DSL FROM 4A	1				4	
RA1	ATM RESID 1/2/5 (Arab)	1	1	2	1	1	5
RB1	ATM RESID 1/2/5 (Bah)	1	1	2	1	1	5
HD3	HVY DSL 3 & 4 CDU	3			3	4	
VA3	VAC RES 3 & 4 CDU	3			3	4	
	DEFERRED CUTS						
W11	1 VDU WGO POOL	9	1	1			
L11	1 VDU LVGO POOL	9	1	1			
V11	1 VDU VAC RES POOL	9	1	1			
LW1	1 VDU LWGO POOL (Asp)	9	1	1			
W21	1 VDU LVGO POOL (Asp)	9	1	1			
L21	1 VDU VAC RES POOL (A)	9	1	1			
BS1	1 VDU BSGO	9	1	1			
AS1	1 VDU ASPHALT	9	1	1			
W31	1 VDU WGO POOL (BSGO)	9	1	1			
L31	1 VDU DGO POOL (BSGO)	9	1	1			
BS3	1 VDU BSGO (BSGO)	9	1	1			
V31	1 VDU VAC RES POOL (BSGO)	9	1	1			
W15	5 VDU WGO POOL	9	1	1	1		1
L15	5 VDU LVGO POOL	9	1	1	1		1
H15	5 VDU HVGO POOL	9	1	1	1	1	1
V15	5 VDU VAC. RESID POOL	9	1	1	1	1	1
W25	5 VDU WGO POOL (Asp)	9					1
L25	5 VDU LVGO POOL (Asp)	9					1
H25	5 VDU HVGO POOL (Asp)	9					1
AS5	5 VDU ASPHALT	9					1
W16	6 VDU WGO AT 50 MBPD	9	1	1			1
L16	6 VDU LVGO AT 50 MBPD	9	1	1	1		1

Table 13-19
Continued

TABLE CRDCUTS	TEXT	TYPE	LC1	LC2	LC3	LC4	LC5*
H16	6 VDU HVGO AT 50 MBPD	9	1	1	1	1	1
V16	6 VDU VR AT 50 MBPD	9	1	1	1	1	1
W26	6 VDU WGO AT 65 MBPD	9	1	1			1
L26	6 VDU LVGO AT 65MBPD	9	1	1	1		1
H26	6 VDU HVGO AT 65MBPD	9	1	1	1	1	1
V26	6 VDU VR AT 65 MBPD	9	1	1	1	1	1
W46	6 VDU WGO FROM W11	9	1	1			
L46	6 VDU LVGO FROM W11	9	1	1			
H46	6 VDU HVGO FROM W11	9	1	1			
W56	6 VDU WGO FROM W11	9	1	1			
L56	6 VDU LVGO FROM W11	9	1	1			
H56	6 VDU HVGO FROM W11	9	1	1			

0. This indicates that cut yield is identified in the assay data, but this cut is produced by downstream separation, in a saturated gas plant and not on a crude unit.
1. This indicates that this a straight-run atmospheric cut.
2. This indicates that it is atmospheric residuum, which may be used elsewhere or fractionated in a vacuum unit. If an atmospheric resid is always directed to a vacuum unit, it is omitted from the cutting scheme in this table.
3. This indicates that it is a straight-run vacuum cut.
9. This indicates it is a deferred cut that is not produced on a crude distillation unit but in a downstream unit.

The other column names in this table are the three-character tags for the logical crude units and must exactly match the column names of the CRDDISTL Table. The entry at each intersection is the pool number to which the cut from each logical crude unit is directed.

For example, if this table contains a cut ABC, this stream yields streams ABC in pool 1, AB2 in pool 2, and AB3 in pool 3. Thus, when a stream is segregated, the model automatically constructs additional stream tags to identify the segregated stream. The third character in the stream tag is replaced with a pool number for pool 2 onward.

SCRD TABLE

The SCRD Table (Table 13-20) gives the disposition of crudes processed by the refinery to various crude distillation units. But only those crudes with nonblank entries in the material balance rows for crudes are available as potential feed to that logical crude unit. Therefore, if a crude is omitted from the logical crude unit, it will not be processed on that unit. Thus, Table 13-20 shows that crude ABP (Arab light) is processed on crude units 3, 4, and 5, while crude BAH (Bahrain crude) is processed only on crude units 1 and 2.

Tables 13-17 to 13-20 contain all the data on the crudes processed, their disposition, yield and properties, data on the physical atmospheric and vacuum distillation units present, their mode of operation, unit capacities, and utility consumption. The primary cuts from various crude units are pooled or segregated as per pooling map in the CRDCUTS Table. Thus, all refinery atmospheric distillation data is maintained in these tables. The CDU models are automatically generated from them by the LP package.

CDU SUBMODEL STRUCTURE

It may be useful to review exactly how a matrix generator program processes data in the Assay Table to produce material and property balances for CDU streams. The Assay Table differs from other tables in that it is not included in the matrix but is used by the program to build one or more CDU tables, which are included in the matrix.

The name of actual CDU submodel tables built by the matrix generator program is typically concocted by adding a character S (to denote submodel) before the column names of the CRDDISTL Table. Thus, if the first column in this table is LC1, the first CDU table is named SLC1 (PIMS Refinery LP Package).

The column names in the crude submodel tables are the operation modes of this crude distillation unit. Thus, A1N and A1K are the two operation modes of crude distillation unit SLC1 while processing light Arab crude, and B1N and B1K are the two operation modes while processing Bahrain crude. In the matrix generated from this table, the column names are SLC1A1N, SLC1A1K, SLC1B1N, and SLC1B1K. The row names would be identical to the table CRDCUTS row names; for example, in this case, VBALGA1,V-BALC41, VBALLS1, and so on. The coefficients at row/column intersections are the yields of various cuts of data entered in the Assay Table.

The atmospheric residuum from crude units becomes feed to VDUs. To avoid unnecessary multiplicity of streams, only one atmospheric

Table 13-20
Disposition of Crudes

TABLE SCRD	TEXT	A1N	A1K	A2N	A2K	A3N	A3K	A4N	A4K	A5N	A5K	B1N	B1K	B2N	B2K	B3N	B3K	B4N	B4K	B5N	B5K
VBALABP	AL CRUDE	1	1	1	1	1	1	1	1	1	1										
VBALBAH	BAH CRUDE											1	1	1	1	1	1	1	1	1	1
VBALA1N	AB to 1 CDU Normal	−1																			
VBALA1K	AB to 1 CDU KRR		−1																		
VBALA2N	AB to 2 CDU Normal			−1																	
VBALA2K	AB to 2 CDU KRR				−1																
VBALA3N	AB to 3 CDU Normal					−1															
VBALA3K	AB to 3 CDU KRR						−1														
VBALA4N	AB to 4 CDU Normal							−1													
VBALA4K	AB to 4 CDU KRR								−1												
VBALA5N	AB to 5 CDU Normal									−1											
VBALA5K	AB to 5 CDU KRR										−1										
VBALB1N	Bah to 1 CDU Normal											−1									
VBALB1K	Bah to 1 CDU KRR												−1								
VBALB2N	Bah to 2 CDU Normal													−1							
VBALB2K	Bah to 2 CDU KRR														−1						
VBALB3N	Bah to 3 CDU Normal															−1					
VBALB3K	Bah to 3 CDU KRR																−1				
VBALB4N	Bah to 4 CDU Normal																	−1			
VBALB4K	Bah to 4 CDU KRR																		−1		
VBALB5N	Bah to 5 CDU Normal																			−1	
VBALB5K	Bah to 5 CDU KRR																				−1

resid stream is produced from the operation of one crude distillation column, irrespective of number of crudes processed there or the number of operation modes of the CDUs. This is done by pooling the various resid streams from different modes of a crude column, as shown next for crude distillation column 1 (SLC1). Also the yield and properties of streams produced from the vacuum distillation of this resid are determined here, as these properties depend on the properties of the composite resid stream generated here, even though the vacuum distillation streams are not produced here. A part of Table SLC1 follows, presenting pooling of resids from various operation modes of crude distillation column SLC1:

	A1N	A1K	B1N	B1K	AR1
VBALAR1	−0.5224	−0.5224	−0.5330	−0.5330	
RBALAR1	−0.5224	−0.5224	−0.5330	−0.5330	1
ISPGAR1	0.9463	0.9463	0.9459	0.9459	
RSPGAR1	−0.4943	−0.4943	−0.5041	−0.5041	999
ISULAR1	3.14	3.14	3.38	3.38	
IVBIAR1	446.1	446.1	431.7	431.7	
RSULAR1	−1.6403	−1.6403	−1.8015	−1.8015	999
RVBIAR1	−233.042	−233.042	−230.096	−230.096	999

The properties of the pooled stream AR1 are calculated next.

For example, consider the specific gravity of the pooled resid stream AR1. This stream is generated by pooling volumes in the VBALAR1 row. Row RBALAR1, which has the same coefficients as row VBALAR1, represents how many barrels of resids from each operation mode of SLC1 are used to form the pool. The specific gravity of individual cuts is given by row ISPGAR1 in the Assay Table. Row RSPGAR1 coefficients are formed by multiplying coefficients in row ISPGAR1 with the coefficient in row RBALAR1. For example, the coefficient of row RSPGAR1 in column A1N is the product of 0.9463*−0.5224, or 0.4943. The activity of this row is the sum of SG*barrels for the pooled stream. The SG of the composite stream can be calculated by dividing the row activity of RSPGAR1 by the row activity of RBALAR1, if column activities are known. Other properties of the composite streams can similarly be calculated.

It may be noted that, even though the rows VBALAR1 and RBALAR1 exhibit the same coefficients in the SLC1 Table, there is an important distinction between them. VBALAR1 is a material balance row, representing the actual physical production of atmospheric residue. RBALAR1, on the other hand, is a property balance row, which provides the denominator for computation of the average specific gravity of the pooled resid.

DBAL Rows (Deferred Cuts)

In the Assays Table, the yields for all atmospheric cuts, such as LPG, light naphtha, kerosene, or diesel, are represented by entries in VBAL rows; for example, VBALLS1 for LSR, VBALKN1 for kerosene yield, and VBALAR1 for atmospheric resid streams. This is because these streams are produced directly from CDUs and their volumes as well as properties are determined in the CDUs.

On the other hand, the vacuum product streams (LVGO, HVGO, V. RESID) and certain other streams, which are not produced on the CDU, are represented by DBALxxx type rows; for example, DBALW11, DBALL11, and DBALH11 represent WGO, LVGO, and HVGO streams from VDU1 from the distillation of atmospheric resid from the CDU1. The presence of these deferred products in the Assays Table reflects the fact that their properties depend on the crude mix and CDU fractionation. That they are represented by DBAL and not VBAL rows reflects that the option of exactly what volume of each stream is to be actually produced lies with the vacuum distillation units.

In the Assays Table the properties of the various atmospheric cuts and deferred cuts are represented by the suffix I:

ISPGL11	Specific gravity of DGO.
ISULL11	Sulfur of DGO.
IVBIL11	Viscosity blending index of DGO.

Consider distillate gas oil stream DGO, produced from VDU 1. This stream has no VBAL rows in the Assays Table. To calculate the specific gravity of a blend of streams, the LP multiplies the RBALL11 row with ISPGL11 rows and again the resulting "gravity*barrels" are placed in row RSPGL11. Row RBALL11 has the same coefficients as row DBALAR1, representing how many barrels of DGO distillate from each operation mode of SLC1 are used to form the pool. RBALxxx is used as the denominator to calculate the average stream property. The numerator is provided by the activity of row RSPGL11.

	A1N	A1K	B1N	B1K	L11
DBALL11	−0.2544	−0.2544	−0.2709	−0.2709	
RBALL11	−0.2544	−0.2544	−0.2709	−0.2709	1
ISPGL11	0.9093	0.9093	0.9122	0.9122	
RSPGL11	−0.2313	−0.2313	−0.2471	−0.2471	999

VDU Yield as a Property of Vacuum Resids

In the Assay Table, there is a group of rows with special significance. This group of I rows specify a special set of properties of the atmospheric resid streams. These represent the yield of various products in the VDU from distillation of the atmospheric resids, for example, the following rows:

IW11AR1	Yield of WGO from atmospheric resid AR1 on VDU1.
IL11AR1	Yield of DGO from atmospheric resid AR1 on VDU1.
IV11AR1	Yield of V. RESID from atmospheric resid AR1 on VDU1.

Although treated as properties in the Assays Table, these are the yields of products from the vacuum distillation of atmospheric resid streams, called the *pseudoproperties* of atmospheric resid because they are presented as similar to the properties of the atmospheric resid in I-type rows.

Consider a portion of the Assays Table data for processing of Arab and Bahrain crudes on CDU1. The following data present potential yields and properties of various vacuum distillation cuts from processing atmospheric resids produced from various operation modes of atmospheric crude distillation column CDU1, on vacuum distillation column VDU6:

	A1N	A1K	B1N	B1K
VBALAR1	−0.5224	−0.5224	−0.5330	−0.5330
*				
DBALW26	−0.0020	−0.0020	−0.0030	−0.0030
DBALL26	−0.1280	−0.1280	−0.1210	−0.1210
DBALH26	−0.2220	−0.2220	−0.2210	−0.2210
DBALV26	−0.1700	−0.1700	−0.1710	−0.1710
*				
IW26AR1	0.0040	0.0040	0.0050	0.0050
IL26AR1	0.2452	0.2452	0.2352	0.2352
IH26AR1	0.4250	0.4250	0.4282	0.4282
IV26AR1	0.3256	0.3256	0.3316	0.3316
*				
ISPGW26	0.8200	0.8200	0.8188	0.8188
ISPGL26	0.8705	0.8705	0.8740	0.8740
ISPGH26	0.9348	0.9348	0.9379	0.9379
ISPGV26	1.0254	1.0254	1.0326	1.0326
*				

In this table,

W26 = wet gas oil from distillation of CDU1 atmospheric resid on VDU6.

L26 = LVGO from distillation of CDU1 atmospheric resid on 6VDU6.

H26 = HVGO from distillation of CDU1 atmospheric resid on 6VDU6.

V26 = vacuum resid from distillation of CDU1 atmospheric resid on VDU6.

The yields of vacuum cuts are presented by DBAL rows instead of VBAL rows, indicating that these cuts are not produced on the crude column and the yields indicate only the potential yield of cuts from the vacuum column.

The second set of rows IW26AR1, IL26AR1, IH26AR1, and IV26AR1 are the potential yields of WGO, LVGO, HVGO, and vacuum resid on the atmospheric resid feed (not on the crude) by the distillation of CDU1 atmospheric resids on VDU6. Here, VDU6 yields of various cuts from processing CDU1 resid are indicated as a property of the feed resid.

Rows ISPGW26, ISPGL26, and the like indicate the properties of cuts (WGO, LVGO) from VDU6.

Referring to these Assays Table data, the following structure determines the yield of various vacuum cuts from a vacuum column; for example, VDU6 from a resid coming from mix of crudes processed on CDU1:

	A1N	A1K	B1N	B1K	AR1
RBALAR1	−0.5224	−0.5224	−0.5330	−0.5330	1
*					
RW26AR1	−0.0021	−0.0021	−0.0027	−0.0027	999
RL26AR1	−0.1281	−0.1281	−0.1281	−0.1281	999
RH26AR1	−0.2220	−0.2220	−0.2282	−0.2282	999
RV26AR1	−0.1701	−0.1701	−0.1767	−0.1767	999

Here, the coefficients in row RW26AR1 represent the yield of wet gas oil (WGO) from VDU6. The coefficient in column A1N in this row is obtained by multiplying the corresponding coefficients in row RBALAR1 and row IW26AR1 ($-0.5224 \times 0.0040 = -0.0020$). Similarly, the coefficient in row RV26AR1, column A1N is formed as a product of corresponding coefficients in RBALAR1 and IV26AR1 ($-0.5224 \times 0.3256 = -0.1701$).

The overall yields of vacuum cuts W26 (WGO), L26 (LVGO), H26 (HVGO), and V26 (vacuum resid) from the distillation of composite atmospheric resid from crude unit 1 or SLC1 is determined by dividing the row activity of each RW26AR1, RL26AR1, RH26AR1, and RV26AR1 by the row activity of RBALAR1 once the column activities are known.

The 999 is a placeholder for the first guess of the yield of the vacuum products, required to start the recursion process.

The yields of vacuum cuts determined here are transmitted to various vacuum distillation submodels for use.

Properties of VDU Streams

The properties of a vacuum distillation stream depends on the composition of the atmospheric resids from which the VDU stream is produced. In the LP structure that follows, the specific gravities of W26 (WGO), L26 (LVGO), H26 (HVGO), and V26 (vacuum resid) from VDU6 are determined.

Here, the feed to VDU6 is atmospheric resid from crude distillation unit 1 (SLC1). Row DBALW26 gives the potential yield of WGO from different atmospheric resids from different modes of crude distillation column 1. The coefficients in row RBALW26 are identical to those in row DBALW26. The coefficient in row RSPGW26, for example, in column A1N, is formed by multiplying the coefficient in row RBALW26 with the coefficient in row ISPGW26 ($-0.0020 \times 0.8200 = -0.0016$). The specific gravity of the WGO stream is determined by dividing the activity of row RSPGW26 by the activity of row RBALW26 once the column activities are known:

- Specific gravity of stream W26, wet gas oil from VDU6 processing CDU1 atmospheric resid.

	A1N	A1K	B1N	B1K	W26
DBALW26	−0.0020	−0.0020	−0.0030	−0.0030	
RBALW26	−0.0020	−0.0020	−0.0030	−0.0030	1
RSPGW26	−0.0016	−0.0016	−0.0025	−0.0025	999

- Specific gravity of stream L26, LVGO from VDU6 processing CDU1 atmospheric resid.

	A1N	A1K	B1N	B1K	L26
RBALL26	−0.1280	−0.1280	−0.1210	−0.1210	1
RSPGL26	−0.1114	−0.1114	−0.1058	−0.1058	999

- Specific gravity of stream H26, HVGO from VDU6 processing CDU1 atmospheric resid.

	A1N	A1K	B1N	B1K	H26
RBALH26	−0.2220	−0.2220	−0.2210	−0.2210	1
RSPGH26	−0.2075	−0.2075	−0.2073	−0.2073	999

- Specific gravity of stream V26, vacuum resid from VDU6 processing CDU1 atmospheric resid.

	A1N	A1K	B1N	B1K	V26
RBALV26	−0.1700	−0.1700	−0.1710	−0.1710	1
RSPGV26	−0.1743	−0.1743	−0.1766	−0.1766	999

Other properties (sulfur, viscosity blend index, pour index) of various vacuum cuts are determined in an identical manner.

We see that both the properties and potential yields of vacuum cuts are determined in an atmospheric crude distillation model, where the feed to vacuum distillation unit originates and relative ratios of various crudes or their operating modes of CDU are available. The yield and property data of vacuum cuts can be retrieved in VDU submodels to give the proper yield of the vacuum stream from each atmospheric resid charged to a given vacuum unit.

The advantage of modeling vacuum yields as pseudoproperties of atmospheric resids in the Assays Table is that all vacuum unit yield data are maintained in a single table, the Assays Table. The use of pseudoproperties allows the flexibility to add unlimited number of crudes to any CDU and still obtain the correct yields in VDU submodels without modifying the VDU submodels in any way.

Although the use of deferred distillation rows and a number of pseudoproperty rows in the Assays Table appears to complicate the model, this additional structure in the table enormously simplifies the modeling

VDUs as well as the addition of crude to the model and model maintenance in general. The advantages of deferred distillation becomes apparent in VDU submodels.

VACUUM DISTILLATION UNIT MODELING

In refineries in which each CDU has its own associated VDU, modeling a composite crude and vacuum unit becomes easy, and yields from the vacuum unit are treated exactly like those from CDU. However, in refineries where atmospheric residuum from a given CDU can go to a number of VDUs, one cannot treat CDUs and VDUs as a single combination, since one does not know in advance in which VDU a given atmospheric residue will be processed nor which set of vacuum streams will be produced.

Consider the following VDU6 model. Here, the feed is AR1, the atmospheric resid from CDU1. The product streams are

W62	Wet gas oil.
L62	LVGO.
H62	HVGO.
V62	Vacuum resid.

In the SVD6 Table,

	AR1	W26	L26	H26	V26
VBALAR1	1				
VBALW26		1			
VBALL26			1		
VBALH26				1	
VBALV26					1
VBALWG6		−1			
VBALVM6			−1		
VBALVH6				−1	
VBALVR6					−1
EW26AR1	−999	1			
EL26AR1	−999		1		
EH26AR1	−999			1	
EV26AR1	−999				1

In rows EW26AR1, EL26AR1, EH26AR1, and EV26, the second to fourth characters match the names of pseudoproperties of AR1, which were defined in the Assays Table to represent the yields on VDU6 of WGO, LVGO, HVGO, and vacuum resid, respectively. In the SVD6 Table, these E (equality) rows all have entries of −999 in column AR1. The matrix generator program will substitute, for −999, the current yield of each vacuum product, as calculated in the Assays Table for CDU1 atmospheric resid. Thus, the correct vacuum yields for a mix of crudes processed on CDU1 is calculated in CDU1 submodel and transmitted to VDU6 submodel in column AR1.

Now, let us see how the yields transmitted into AR1 are utilized. For example, consider the vacuum resid yields represented in row EV26AR1. The program will substitute for −999 in column AR1, the yield of vacuum resids from AR1.

Suppose this is 0.33 or 33%. Then, −0.33 is substituted for −999. Further suppose that 1 mb (million barrels) of CDU1 atmospheric resid AR1 is charged to VDU6; then, the volume placed into row EV26AR1 in column AR1 is as follows:

$$1\,\text{mb AR1} \times 0.33\ (\text{yield of vacuum resid}) = -0.33\,\text{mb vacuum resid}$$

The negative sign denotes production. The only other entry in row EV26AR1 is a positive 1 in column V26. Since this is an equality row that must balance, column or variable V26 takes on an activity equal to the volume of vacuum resid contained in CDU1 atmospheric resid charged to VDU6. The activities of the other columns W26, L26, H26 are similarly determined by these E rows.

Other entries shown in column V26 are −1, representing production, in row VBALVR6 +1, representing consumption, in row VBALV26. Therefore we are actually producing not stream V26, which is VDU6 vacuum resid derived from CDU1 atmospheric resid, but VR6, the overall vacuum resid produced on VDU6 from all atmospheric resids from different CDUs. This is consistent with the physical reality of the refinery, where all atmospheric resids are processed as a mixture to produce a single set of vacuum products from a VDU.

A vacuum distillation unit may have more than atmospheric resid feed. Let us add one more resid, AR3 coming from CDU3, to the preceding structure, as shown next, this time showing only vacuum resid production:

	AR1	V26	AR3	V36	VR6
VBALAR1	1				
VBALAR3			1		
VBALV26		1			
VBALV36				1	
VBALVR6		−1		−1	
EV26AR1	−999	1			
EV36AR3			−999	1	
*					
RBALVR6		−1		−1	1
RSPGVR6		−999		−999	999
RSULVR6		−999		−999	999
RVB1VR6		−999		−999	999

We see that the structure in this table for AR3 is exactly parallel to that for AR1. Column V36 has activity equal to the volume of VDU6-derived vacuum resid derived from CDU3, just as the activity of column V26 represents the VDU6 vacuum resid derived from CDU1.

Note that both columns V26 and V36 have entries of −1 in row VBALVR6, showing that these resids coming from different CDUs combine into a single vacuum resid stream, VR6. Columns V26 and V36 have +1 entries in material balance rows VBALV26 and VBALV36, indicating that these streams are consumed to form stream VR6.

To estimate the properties of the composite vacuum resid stream, row RBALVR6 shows the components that form the stream, in the form of columns that have −1 entries in this row, that is, V26 and V36. The properties (SG, SUL, VBI, etc.) of V26 and V36 are calculated in the CDU1 and CDU3 submodels and transmitted here to replace the placeholders −999. Placeholder 999, in column VR6, is the first guess of the pooled stream to start the recursion process.

To summarize, the advantage of modeling vacuum distillation with deferred cuts and the stream's pseudoproperties are as follows:

1. The calculation of all VDU yields and stream properties are done in the Assay Table and transmitted to the respective VDU model. The VDU models themselves contain no yield data. All data maintenance is only through the Assays Table.
2. Only one atmospheric resid stream is produced for each CDU, irrespective of the number of crudes processed in it. In the absence

of deferred distillation, one atmos resid is generated for every crude.

3. For each VDU, only one set of vacuum streams is produced, rather than a separate set for each crude/CDU/VDU combination.
4. The streams produced in the model correspond much more closely to streams physically produced in the refinery.
5. All vacuum yields are specified in the Assays Table, eliminating the need to maintain vacuum yield data in VDU submodels.

SINGLE-PRODUCT LP BLENDER

Refinery blending of a cargo is done with following objectives:

1. Meet the requirement of a specific shipment with respect to volume and product specification.
2. Optimum blending; that is, there is no giveaway on product quality and minimum cost to the refinery.
3. Minimize the inventory of stocks by giving priority to reblending tank heels and other unwanted stocks.

To meet these objectives, many refineries use an on-line single-product LP system. This system interfaces with the refinery's LAB system for tank test results and product specifications. The refinery on-line LAB system records, monitors, and reports on streams and product tank test results done by the refinery's laboratory, forming the database for a single-product LP blender.

The on-line single-product LP blender aims to provide minimum-cost blends within user-defined volumetric and specification constraints, using a linear programming algorithm. Optimization of the blend is done on the basis of the prices of blend streams provided by the user. The LP blender system minimizes the cost of the blend produced while meeting product specifications.

For the optimization step, the prices of the blend stocks must be provided. Generally, a very low cost is assigned to stocks such as tank heels and other unwanted stocks to maximize their blending. If the objective is to minimize inventory, arbitrary prices may be used; the assumed price of a stock in this case is inversely proportional to the available inventory.

The user enters only the tank numbers allowed in the blend, the target specifications, and the total blend volume required. Latest tank quality data, such as specific gravity, sulfur, or flash point, are retrieved from the LAB system, once the tank number is entered. The LP next works out the optimum blend composition that meets all given specifications.

The optimum blend composition thus worked out is used for actual blending of cargoes, instead of using past experience with similar blends, manual calculations, or tedious trial and error procedures.

EXAMPLE 13-5

We want to blend 100 mb of a gasoline grade with the following specifications:

RON	MINIMUM	95
MON	MINIMUM	83.5
RVP	kPa MAX	62.0
RELATIVE DENSITY	MIN/MAX	0.7200/0.775
% EVAPORATED AT 70°C	MINIMUM	12

The blending is to be done in tank 74, which contains 8000 bbl of previously shipped gasoline cargo. Determine the most economic blend, using the available stocks. The available blending components and assumed prices are as follows:

STOCK	TANK NO.	PRICE, $/bbl
FCCU LIGHT NAPHTHA	75	17.5
FCCU HEAVY NAPHTHA	77	17.1
REFORMATE	54	19.0
MTBE	79	26.5
COKER LIGHT NAPHTHA	72	15.6
ALKYLATE	73	22.5
GASOLINE (TANK HEEL)	74	15.0

Using a single-product blender system, the tank volume and property data are retrieved from the LAB system, which contains the latest test results done on these tanks. The user insert only the blend component prices for optimization calculations and the total volume of the blend required. The following table is the result:

STOCK	TANK NO.	AVAILABLE VOL, mb	SG	RON, CLEAR	MON, CLEAR	RVP, kPa	% DISTILLED, 70°C
FCCU LIGHT NAPHTHA	75	60.5	0.7095	93	82.7	63	51.0
FCCU HEAVY NAPHTHA	77	40.0	0.8390	93.8	83.2	0	0
REFORMATE	54	20.0	0.7830	96.5	86.4	54.6	10.5
MTBE	79	15.5	0.7450	112.5	100.0	56.7	100
COKER LIGHT NAPHTHA	72	25.4	0.7030	74	65.8	53.2	30
ALKYLATE	73	10.3	0.6845	97.8	94.5	51.8	10.0
GASOLINE (TANK HEEL)	74	8.0	0.7550	93	83	62.0	15.0

The problem is converted into an LP model as presented next. Here, T75, T77, T54, BLN, and the like are variables and their values are found subject to the following conditions. Find

$$\mathrm{T75, T77, T54, T79, T72, T73, T74, BLN} \geq 0$$
$$\mathrm{BLN} = 100$$

such that

$$\mathrm{T75} \leq 60.5$$
$$\mathrm{T77} \leq 40.0$$
$$\mathrm{T54} \leq 20.0$$
$$\mathrm{T79} \leq 15.5$$
$$\mathrm{T72} \leq 25.4$$
$$\mathrm{T73} \leq 10.3$$
$$\mathrm{T74} = 8.0$$

and the following constraints

	T75	T77	T54	T79	T72	T73	T74	BLN	
MAT. BAL.	1	1	1	1	1	1	1	−1	= 0
SG (MIN)	0.7095	0.8390	0.7830	0.7450	0.7030	0.6845	0.7550	−0.7200	≥ 0
SG (MAX)	0.7095	0.8390	0.7830	0.7450	0.7030	0.6845	0.7550	−0.7750	≤ 0
RON	93.0	93.8	96.5	112.5	74.0	97.8	91.0	−95.0	≥ 0
MON	82.7	83.2	86.4	100.0	65.8	94.5	81.0	−83.5	≥ 0
RVP	63.0	0	54.6	56.7	53.2	51.8	62.0	−62.0	≤ 0
DISTILLED, 70°C	51.0	0	10.5	100.0	30.0	10.0	15.0	−12.0	≤ 0

and such that

$$Y = 17.5^*(T75) + 17.1^*(T77) + 19.0^*(T54) + 26.5^*(T79) + 15.6^*(T72) + 22.5^*(T73) + 15.0^*(T74) \text{ is minimum}$$

The blend composition and properties are found on solution of the preceding problem, as follows:

BLEND COMPONENT	VOLUME, mb
LIGHT CAT NAPHTHA	41.69
HEAVY CAT NAPHTHA	30.00
REFORMATE	13.74
MTBE	6.56
COKER LIGHT NAPHTHA	0
ALKYLATE	0
TANK HEEL	8.00
TOTAL BLEND	100.00

Gasoline blend properties are as follows:

PROPERTY	SPECIFICATION	BLEND
SG	0.720–0.775	0.764
RON	95, MIN	95.2
MON	83.5, MIN	84.8
RVP	62 kPa, MAX	42.5
% DISTILLED, 70°C	12% (VOL), MIN	30.5

NOTES

1. For example, IBM MPSX/370 or CPLEX Optimisation Inc.
2. Aspen Technologies Company, originally developed by Bechtal Inc.
3. J. S. Bonner, "Advance Pooling Techniques in Refinery Modeling." Bonner and Moore Associates GmbH seminar Wiesbaden, Germany, Oct 19–21, 1987.
4. G. B. Dantzig, *Linear Programming and Extensions*. Princeton, NJ: Princeton University Press, 1946.
5. The LP packages from different vendors may have different row and column naming conventions. The one described here is from the PIMS from Aspen Technology.