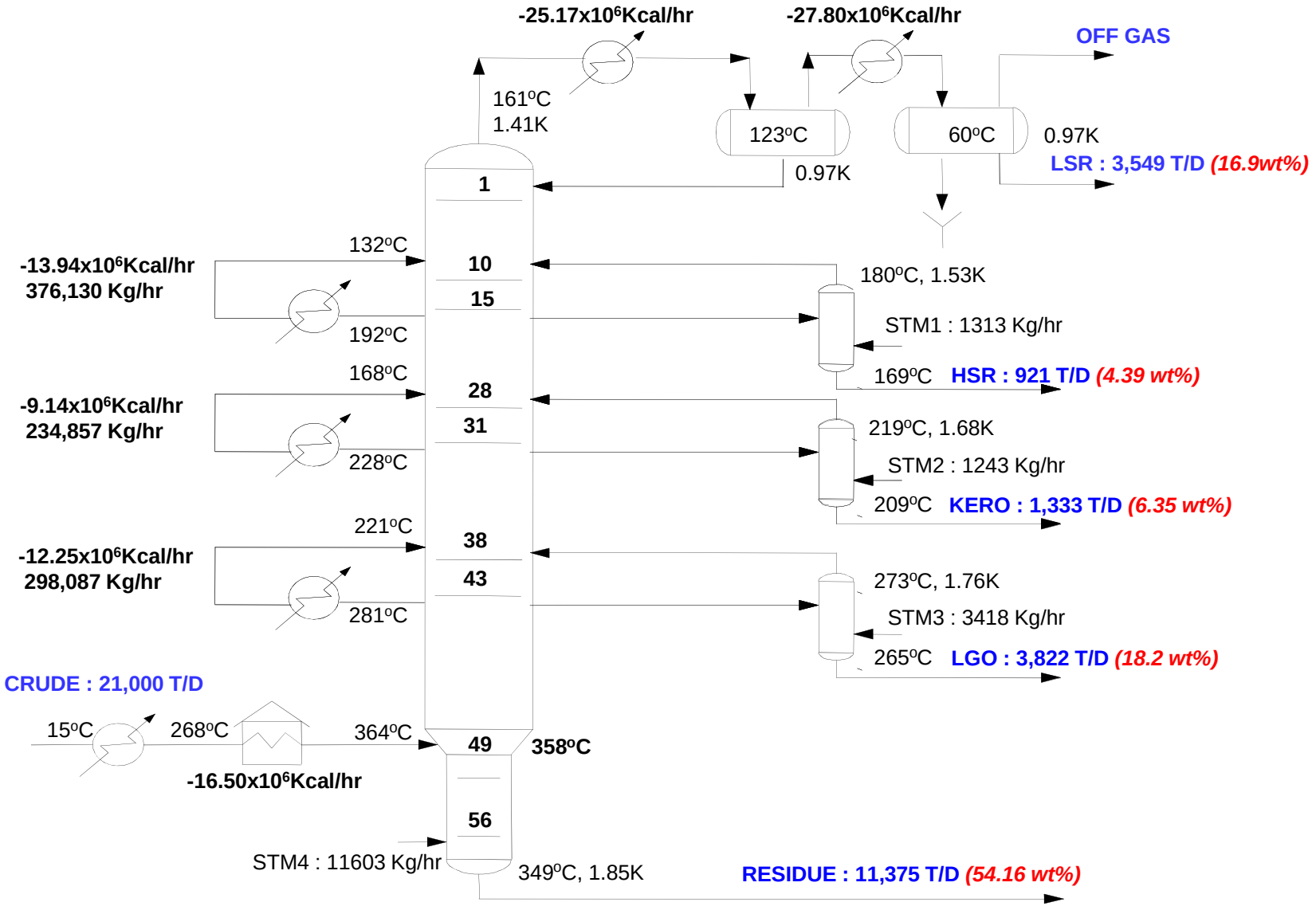
Crude Distillation Unit Simulation using PRO/II with PROVISION for FPCC

Prepared by Dr. Jungho Cho

Minimum Information for Crude Distillation Unit Simulation

- **Whole crude TBP data**
- **Whole crude API**
- **Lightends analysis about up to C4**

Modeling an Atmospheric Crude Tower



Problem Description:

- A crude unit is designed to process 21,000 tons per day of 50% Arabian heavy crude and 50% Arabian light crude. The desired products are shown in the next slide, with specifications in Table 1.

- 250^{o}C steam (assumed to be saturated) is available for stripping. The condenser is to operate at 123^{o}C and 0.97 Kg/cm^{2}G.

- An initial simulation model was constructed as shown in the above slide. ASTM D86 95% temperatures were used for HSR, Kerosene and LGO. The overflash (0.03) was set as a specification. A partial condenser was used to meet the desired temperature of 123^{o}C.

ASTM D86 Temperatures for Side Distillates Products

Table 1 : Product Specification of Each Side Distillates					
	NAPHTHA	HSR	KEROSENE	LGO	RESIDUE
IBP	69	137	168	218	***319***
5 %	71	**165** *(162)*	**198** *(190)*	**246** *(238)*	***368***
10 %	74	**172** *(171)*	**203** *(199)*	**254** *(246)*	***381***
30 %	88	**179** *(175)*	**210** *(205)*	**268** *(265)*	***454***
50 %	**104** *(104)*	**183** *(176)*	**215** *(209)*	**283** *(282)*	***533***
70 %	**122** *(129)*	**187** *(180)*	**221** *(215)*	**301** *(301)*	***684***
90 %	**146** *(149)*	**193** *(186)*	**229** *(226)*	**328** *(328)*	***874***
95 %	**153** *(159)*	**196** *(193)*	**235** *(234)*	**337** *(339)*	-
EP	162	204	251	378	-
					D1160

GAP = 12 *(3)*

GAP = 2 *(-3)*

GAP = 11 *(3)*

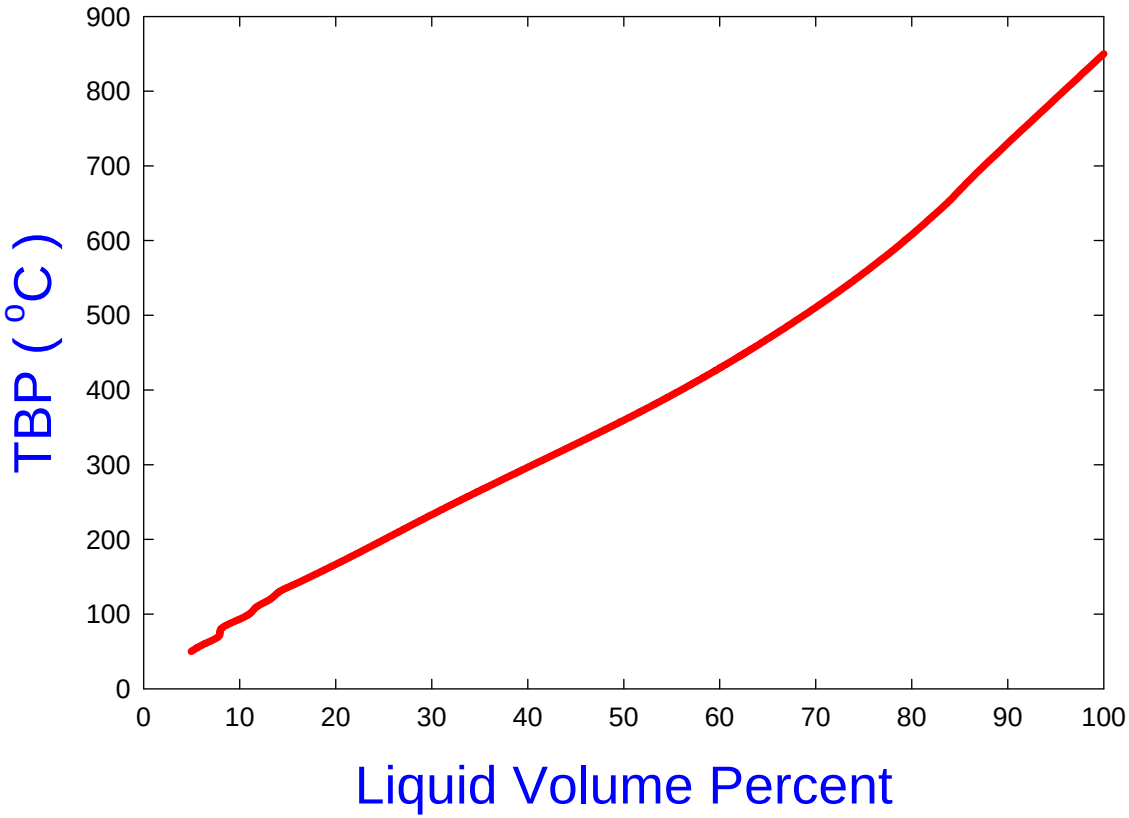
Feedstock Characterization for Crude Oils

Table 2 : Oil 1 (Arabian Heavy Crude Oil : TBP)					
Liq. vol. %	Temp (C)	Liq. Vol. %	Temp (C)	Liq. vol. %	Temp (C)
4.9675	50	29.5540	230	57.3875	410
6.3165	60	31.0779	240	58.7564	420
7.8273	70	32.6249	250	60.0973	430
8.0584	80	34.1912	260	61.4113	440
9.4522	90	35.7731	270	62.6993	450
11.0033	100	37.3668	280	63.9624	460
11.8134	110	38.9686	290	66.4180	480
13.2141	120	40.5747	300	68.7861	500
14.1386	130	42.1813	310	71.0740	520
15.7578	140	43.7847	320	73.2721	540
17.3845	150	45.3812	330	75.3642	560
18.9837	160	46.9669	340	77.3657	580
20.5502	170	48.5379	350	79.2783	600
22.0844	180	50.0883	360	83.6724	650
23.5917	190	51.6115	370	87.5258	700
25.0820	200	53.1026	380	100.0000	850
26.5657	210	54.5616	390		
28.0529	220	55.9896	400		

Feedstock Characterization for Crude Oils

Table 3 : Oil 1 (Arabian Heavy Crude Oil : Specific Gravity)					
Liq. vol. %	Sp. Gr.	Liq. Vol. %	Sp. Gr.	Liq. vol. %	Sp. Gr.
4.9675	0.6348	29.5540	0.8015	57.3875	0.9101
6.3165	0.7603	31.0779	0.8080	58.7564	0.9140
7.8273	0.6643	32.6249	0.8143	60.0973	0.9187
8.0584	0.6733	34.1912	0.8178	61.4113	0.9231
9.4522	0.7736	35.7731	0.8240	62.6993	0.9275
11.0033	0.6953	37.3668	0.8302	63.9624	0.9317
11.8134	0.7128	38.9686	0.8366	66.4180	0.9358
13.2141	0.7342	40.5747	0.8429	68.7861	0.9474
14.1386	0.7258	42.1813	0.8493	71.0740	0.9548
15.7578	0.7349	43.7847	0.8558	73.2721	0.9623
17.3845	0.7427	45.3812	0.9623	75.3642	0.9699
18.9837	0.7512	46.9669	0..8705	77.3657	0.9777
20.5502	0.7592	48.5379	0.8769	79.2783	0.9855
22.0844	0.7662	50.0883	0.8630	83.6724	0.9987
23.5917	0.7736	51.6115	0.8889	87.5258	1.0169
25.0820	0.7809	53.1026	0.8945	100.0000	1.1116
26.5657	0.7879	54.5616	0.9000		
28.0529	0.7948	55.9896	0.9052		

Plot of TBP vs. Liquid Volume % for Arabian Heavy Crude



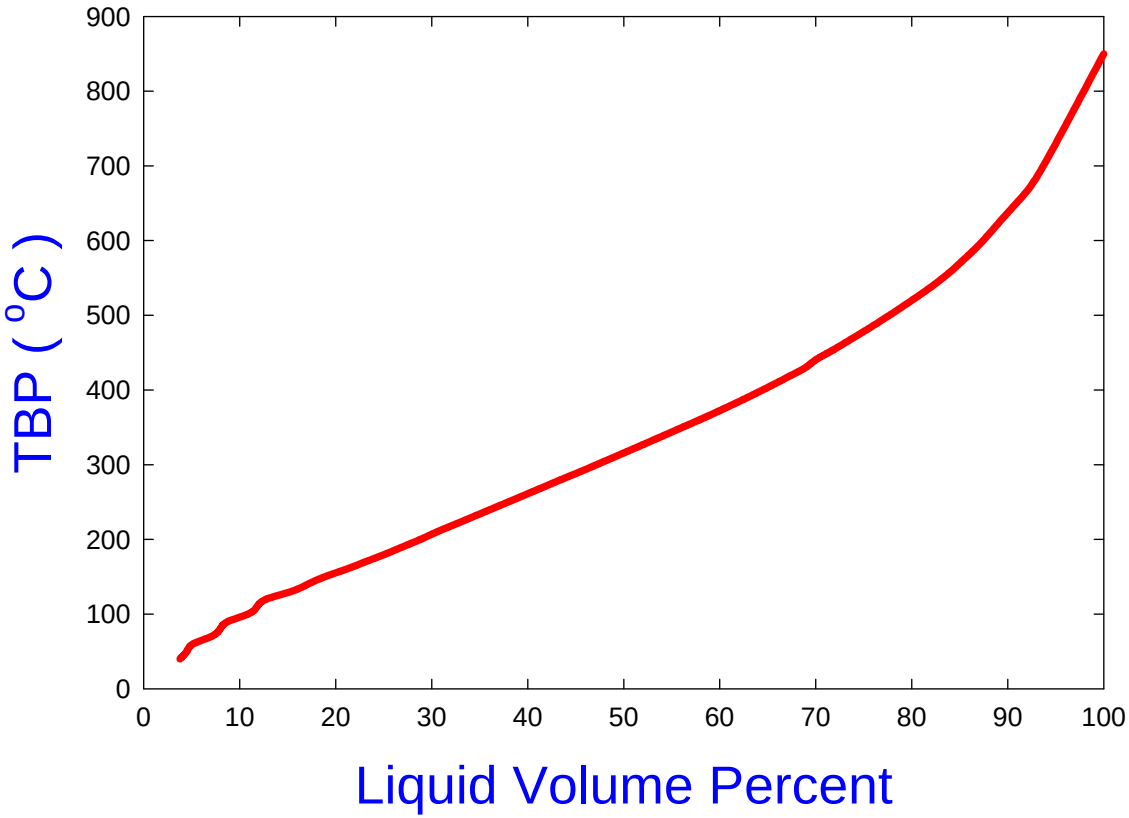
Lightend Analysis for Arabian Heavy Crude

Table 4: Lightends Analysis	
Component	**LV fraction**
C2	**0.0005**
C3	**0.0069**
IC4	**0.0031**
NC4	**0.0130**
Total	***0.0235***

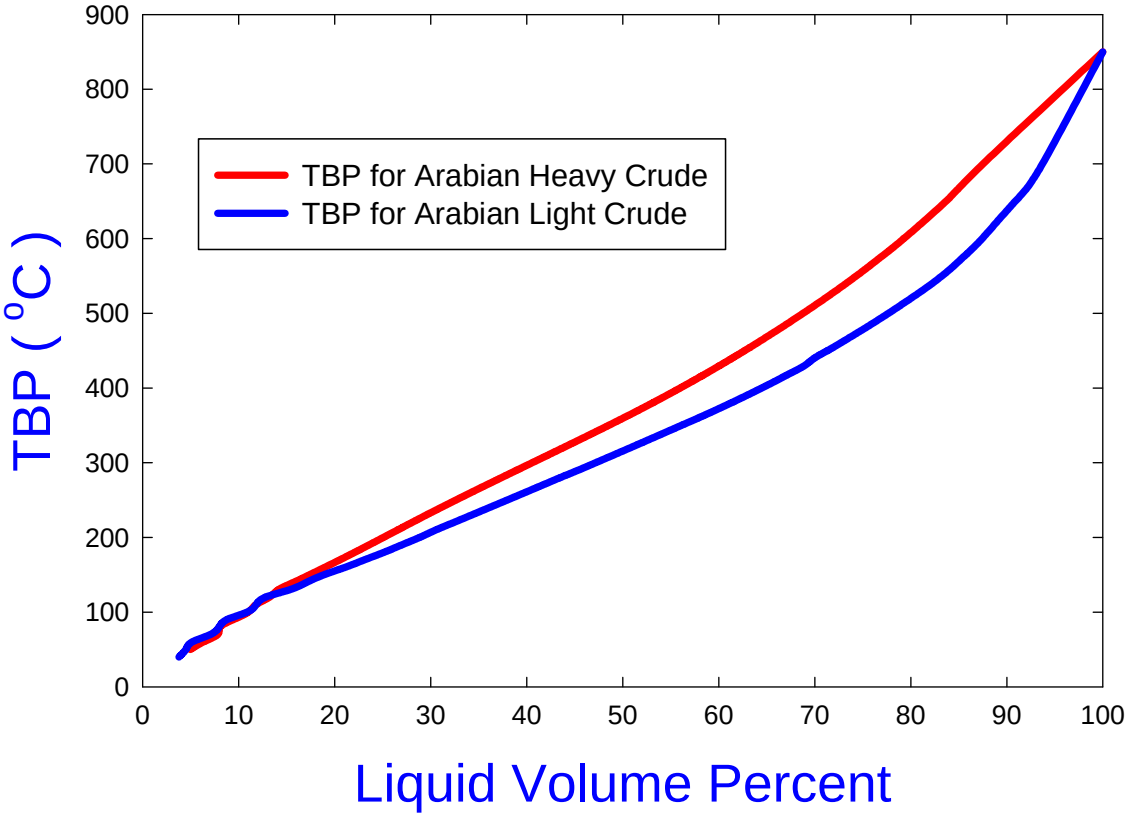
Feedstock Characterization for Crude Oils

Table 5 : Oil 2 (Arabian Light Crude Oil : TBP)					
Liq. vol. %	Temp (C)	Liq. Vol. %	Temp (C)	Liq. vol. %	Temp (C)
3.7904	40	32.4055	220	64.4796	400
4.5061	50	34.2644	230	66.0120	410
5.1447	60	36.1177	240	67.4992	420
7.0606	70	37.9654	250	68.9412	430
7.9677	80	39.8075	260	69.9615	440
8.7810	90	41.6440	270	71.3225	450
10.8900	100	43.4749	280	72.6537	460
11.8191	110	45.3662	290	75.2268	480
12.7902	120	47.1824	300	77.6808	500
15.3348	130	48.9886	310	80.0157	520
17.1090	140	50.7849	320	82.2399	540
18.8832	150	52.5712	330	84.1859	560
21.1010	160	54.3475	340	85.8773	580
23.1071	170	56.1138	350	87.4502	600
25.1326	180	57.8986	360	90.8971	650
26.9911	190	59.6116	370	93.7166	700
28.8573	200	61.2794	380	100.0000	850
30.5410	210	62.9021	390		

Plot of TBP vs. Liquid Volume % for Arabian Light Crude



Comparison of TBP Curve for Arabian Heavy & Light Crude



Feedstock Characterization for Crude Oils

Table 6 : Oil 2 (Arabian Light Crude Oil : Specific Gravity)					
Liq. vol. %	Sp. Gr.	Liq. Vol. %	Sp. Gr.	Liq. vol. %	Sp. Gr.
3.7904	0.6341	32.4055	0.8023	64.4796	0.9075
4.5061	0.6541	34.2644	0.8083	66.0120	0.9104
5.1447	0.6527	36.1177	0.8142	67.4992	0.9147
7.0606	0.6627	37.9654	0.8163	68.9412	0.9188
7.9677	0.7156	39.8075	0.8221	69.9615	0.9228
8.7810	0.7044	41.6440	0.8281	71.3225	0.9267
10.8900	0.7018	43.4749	0.8342	72.6537	0.9304
11.8191	0.7242	45.3662	0.8404	75.2268	0.9358
12.7902	0.7664	47.1824	0.8467	77.6808	0.9406
15.3348	0.7326	48.9886	0.8532	80.0157	0.9476
17.1090	0.7594	50.7849	0.8598	82.2399	0.9549
18.8832	0.7647	52.5712	0.8690	84.1859	0.9624
21.1010	0.7634	54.3475	0.8754	85.8773	0.9702
23.1071	0.7707	56.1138	0.8815	87.4502	0.9784
25.1326	0.7770	57.8986	0.8873	90.8971	0.9914
26.9911	0.7852	59.6116	0.8928	93.7166	1.0095
28.8573	0.7919	61.2794	0.8980	100.0000	1.0982
30.5410	0.7961	62.9021	0.9029		

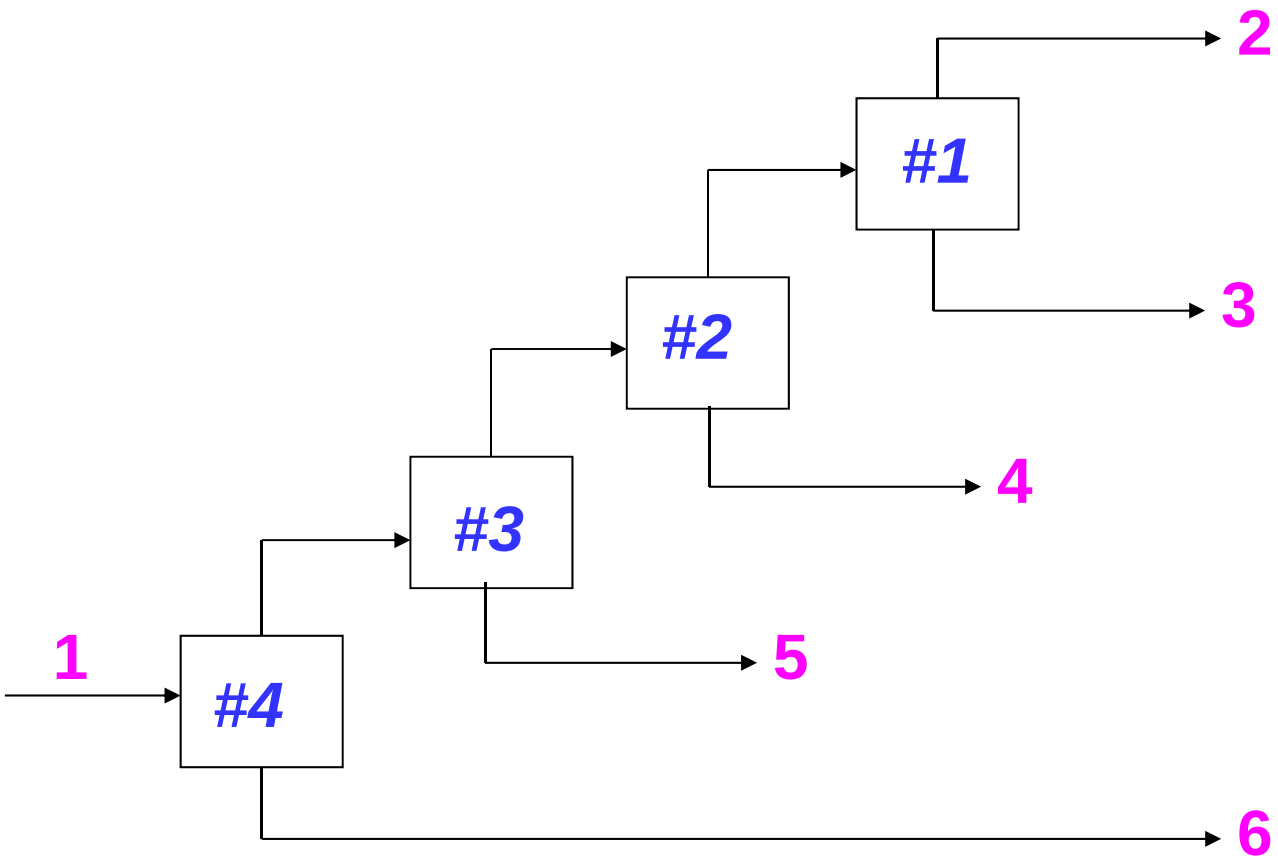
Lightend Analysis for Arabian Light Crude

Table 7: Lightends Analysis	
Component	**LV %**
C2	**0.0001**
C3	**0.0017**
IC4	**0.0018**
NC4	**0.0099**
Total	***0.0235***

Description of PRO/II Input File

File Name	Description
Short-BK10	Shortcut Simulation using BK10 Option
Short-GS	Shortcut Simulation using GS Option
Simple-CDU-BK10	Simplest Crude Column Model (No Pumparounds, No Sidestrippers)
U-type-BK10	Rigorous Crude Column No Pumparounds (BK10 Option)
U-type-GS	Rigorous Crude Column No Pumparounds (GS Option)
With-PA-CDU-BK10	Rigorous Crude Column with Pumparounds (BK10 Option)
With-PA-CDU-GS	Rigorous Crude Column with Pumparounds (GS Option)
With-PA3-CDU-BK10	A Type Crude Column having 3 stages for Each Sidestrippers (BK10)
With-PA4-CDU-BK10	A Type Crude Column having 4 stages for Each Sidestrippers (BK10)
W-PA-CDU-BK10-S1	
W-PA-CDU-BK10-S2	
W-PA-CDU-BK10-S3	

Shortcut Simulation



Part 1: Shortcut Simulation

```
TITLE PROB=SHORT,PROJECT=FPCC,USER=DR_JHCHO
 $$ SHORTCUT MODEL FOR CRUDE UNIT TO CHECK PRODUCT RATES $$
  DIME METRIC, LIQV=BBL
  PRINT STREAM=PART, TBP, INPUT=NONE
 COMP DATA
  LIBID 1,H2O/2,C2/3,C3/4,IC4/5,NC4/6,IC5/7,NC5
 ASSAY CONV=API63
 THERMO DATA
  METHODS SYSTEM=BK10
 STREAM DATA
 $
  PROP STRM=ARAB-H, TEMP=15, PRES=5.033, RATE(WT)=437500, ASSAY=LV
   SPGR STREAM=ARAB-H, AVG=0.8843,&
   DATA=4.9035,0.6348/*
   4.9657,0.7603/*
   6.3165,0.6643/*
   7.8273,0.6733/*
   8.0584,0.7736/*
   9.4522,0.6953/*
   11.0033,0.7128/*
   11.8134,0.7342/*
   13.2141,0.7258/*
   14.1386,0.7349/*
   15.7578,0.7427/*
   17.3845,0.7512/*
   18.9837,0.7592/*
```

File Name : Short-BK10.bkp

Part 1: Shortcut Simulation *continued*

```
UNIT OPERATIONS DATA
  SHORTCUT UID=S01
   FEED ARAB-H,ARAB-L,STM1,STM2,STM3,STM4
   PROD STREAM=LSR,PHASE=M,PRES=2.443,CUTP(WT)=16.9
   PROD STREAM=HSR,PHASE=L,PRES=2.563,CUTP(WT)=21.25
   PROD STREAM=KERO,PHASE=L,PRES=2.713,CUTP(WT)=27.6
   PROD STREAM=LGO,PHASE=L,PRES=2.793,CUTP(WT)=45.8
   PROD STREAM=RESI,PHASE=L,PRES=2.85
   COND TYPE=MIXED,TEMP=123
   EVALUATE MODEL=REFINE
   SPEC STREAM=LSR,D86(95),VALUE=153
   SPEC STREAM=HSR,D86(5),MINUS,STREAM=LSR,D86(95),VALUE=12
   SPEC STREAM=HSR,D86(95),VALUE=196
SPEC STREAM=KERO,D86(5),MINUS,STREAM=HSR,D86(95),VALUE=2
   SPEC STREAM=KERO,D86(95),VALUE=234
   SPEC STREAM=LGO,D86(5),MINUS,STREAM=KERO,D86(95),VALUE=11
   SPEC STREAM=LGO,D86(95),VALUE=337
   SPEC STREAM=RESI,RATE(WT),VALUE=473958
  FLASH UID=F01
   FEED LSR
   PROD V=VLSR,L=LLSR
   ISO TEMP=123,PRES=2.003
END
```

Result Summary for Shortcut (I)

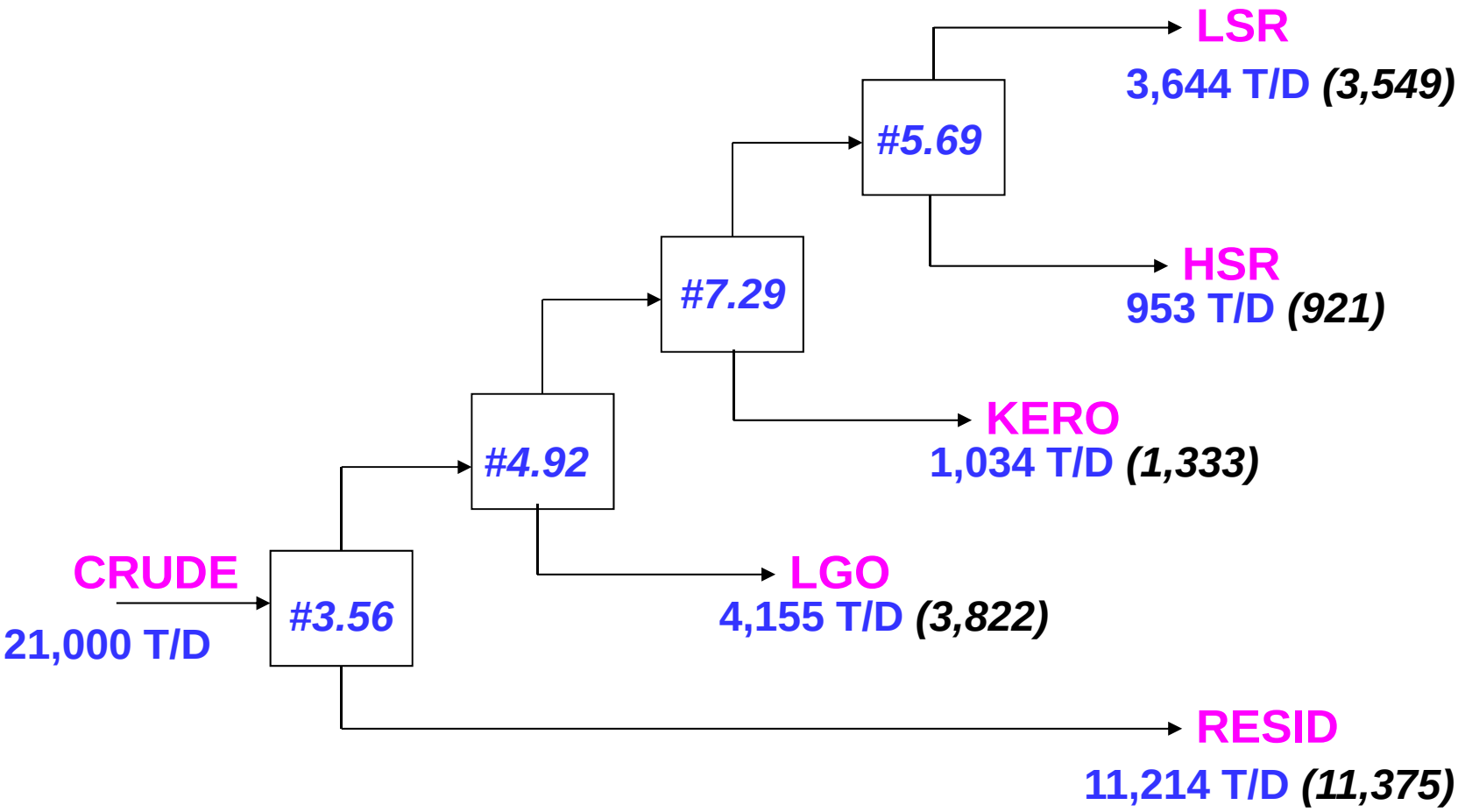
---------- TOTAL STREAM RATES ----------

STREAM + PHASE		MOLES KG-MOL/HR	WEIGHT KG/HR	LIQUID VOL BBL/HR	NORM VAPOR(1) M3/HR	SECTION	NUM TRAYS
LSR	M	2732.26	162701.65	1423.18	61240.95	1	**5.69**
HSR	L	274.33	39715.51	319.51	6148.78	2	**7.29**
KERO	L	255.80	43070.21	336.65	5733.44	3	**4.92**
LGO	L	761.41	173131.08	1282.52	17066.23	4	**3.56**
RESI	L	958.41	473958.25	3067.05	21481.71		
TOTALS		4982.21	892576.70	6428.92	111671.10		**21.45**

SPECIFICATIONS

PARAMETER TYPE	COMP. NUM	SPECIFICATION TYPE	SPECIFIED VALUE	CALCULATED VALUE
STRM LSR		D86 95 PCT	1.530E+02	1.530E+02
STRM HSR		D86 5 PCT	1.200E+01	1.200E+01
STRM HSR		D86 95 PCT	1.960E+02	1.960E+02
STRM KERO		D86 5 PCT	2.000E+00	1.961E+00
STRM KERO		D86 95 PCT	2.340E+02	2.340E+02
STRM LGO		D86 5 PCT	1.100E+01	1.100E+01
STRM LGO		D86 95 PCT	3.370E+02	3.370E+02
STRM RESI		WT RATE	4.740E+05	4.740E+05

Result Summary for Shortcut (II)

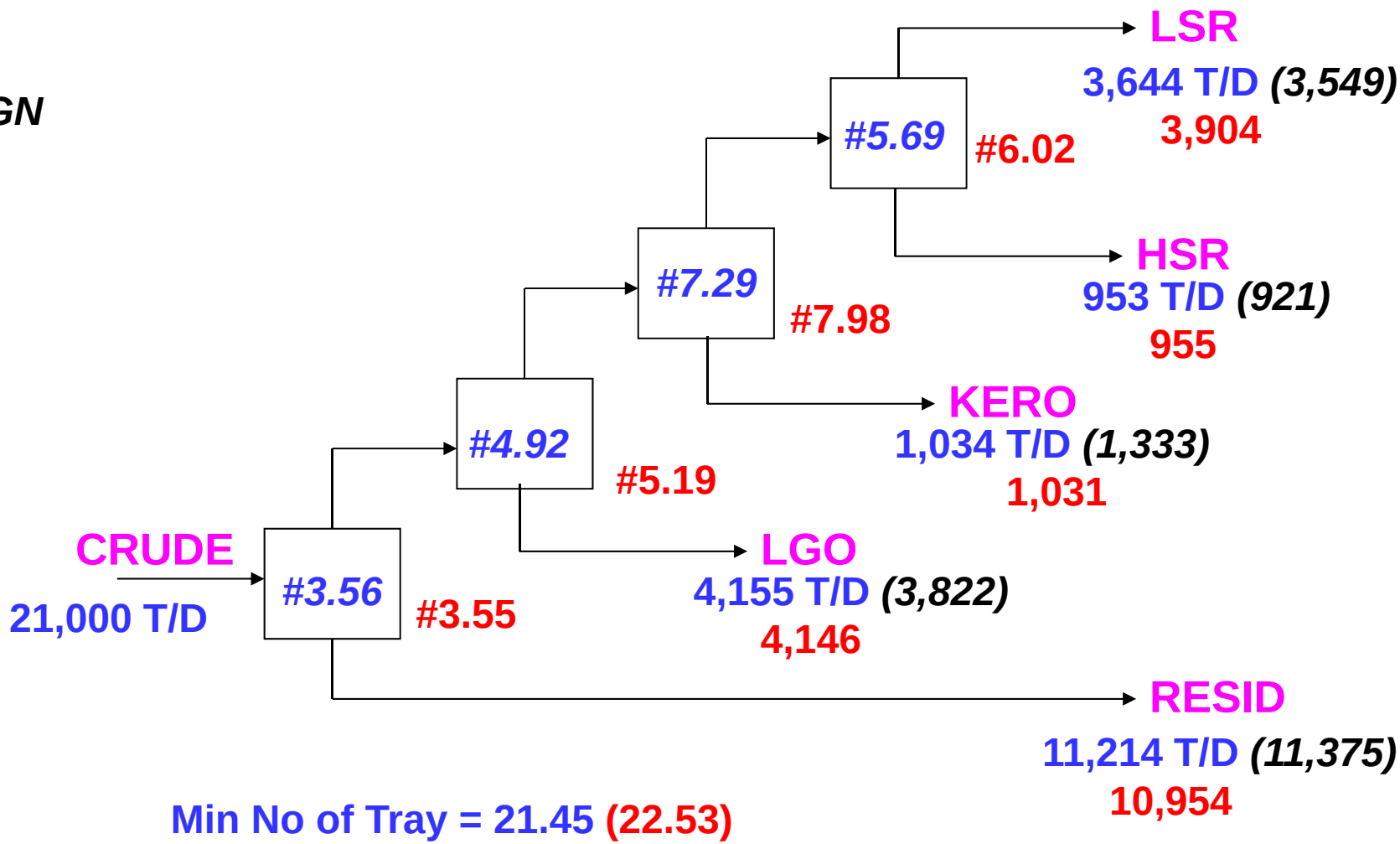


Min No of Tray = 21.45

File Name = SHORT-BK10.out

Shortcut Result for GS Method (III)

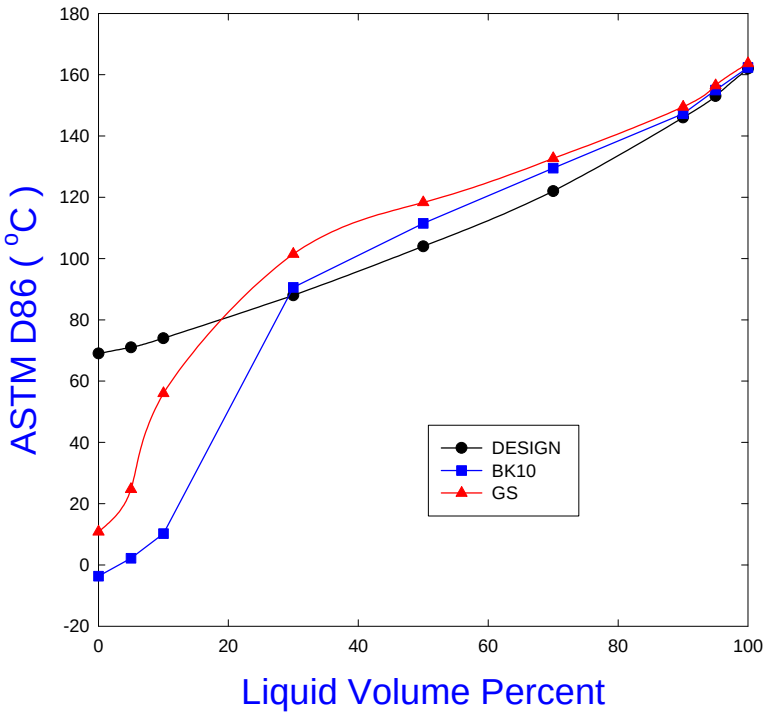
BK10
GS
DESIGN

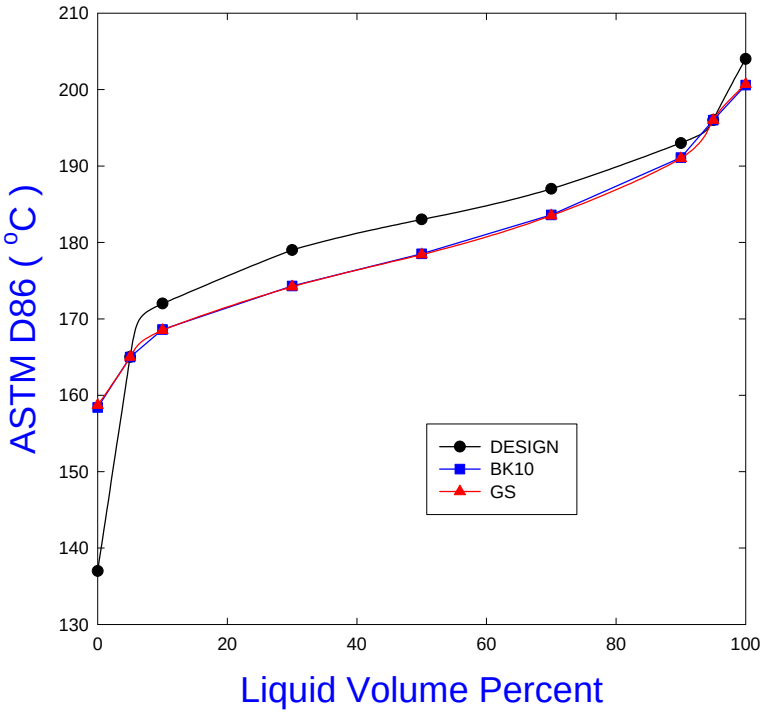


Min No of Tray = 21.45 (22.53)

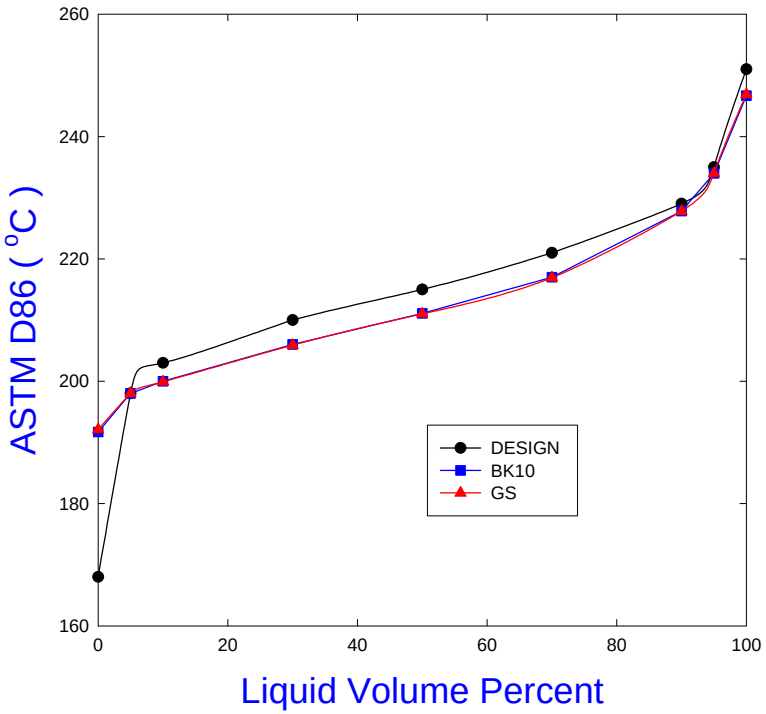
File Name = SHORT-BK10.out
SHORT-GS.out

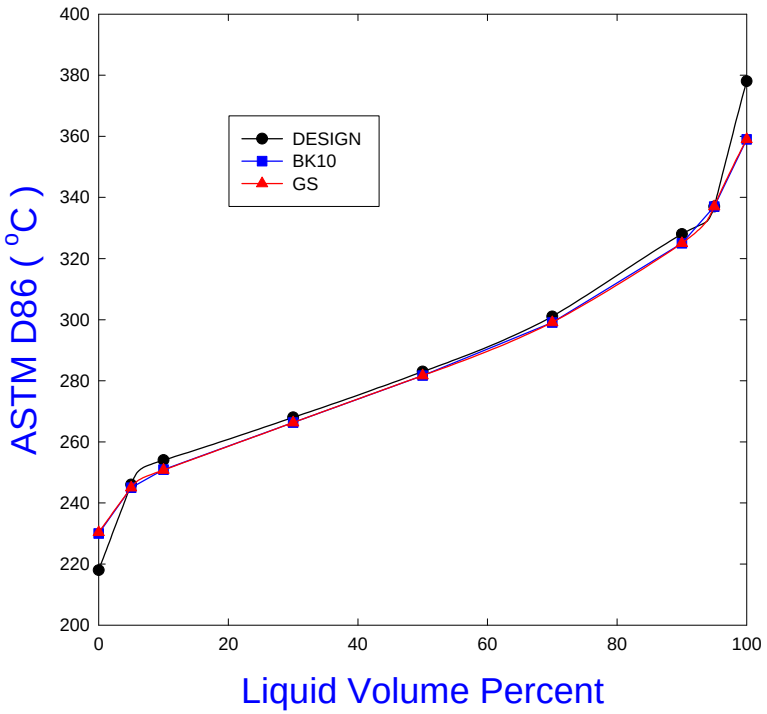
ASTM D86 Curve for LSR & HSR



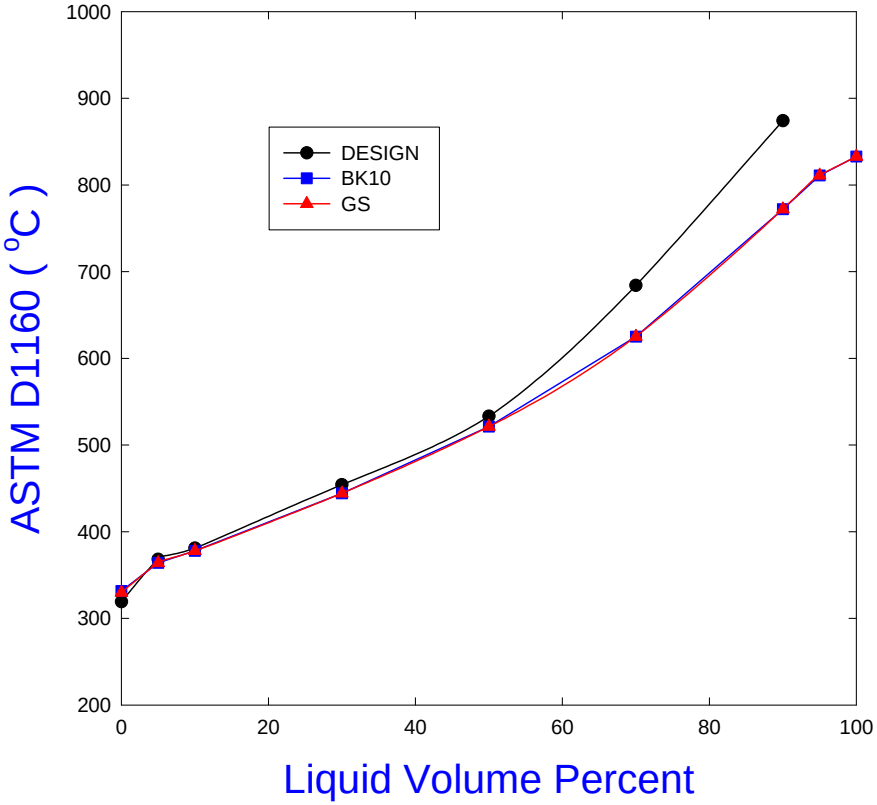


ASTM D86 Curve for KERO & LGO



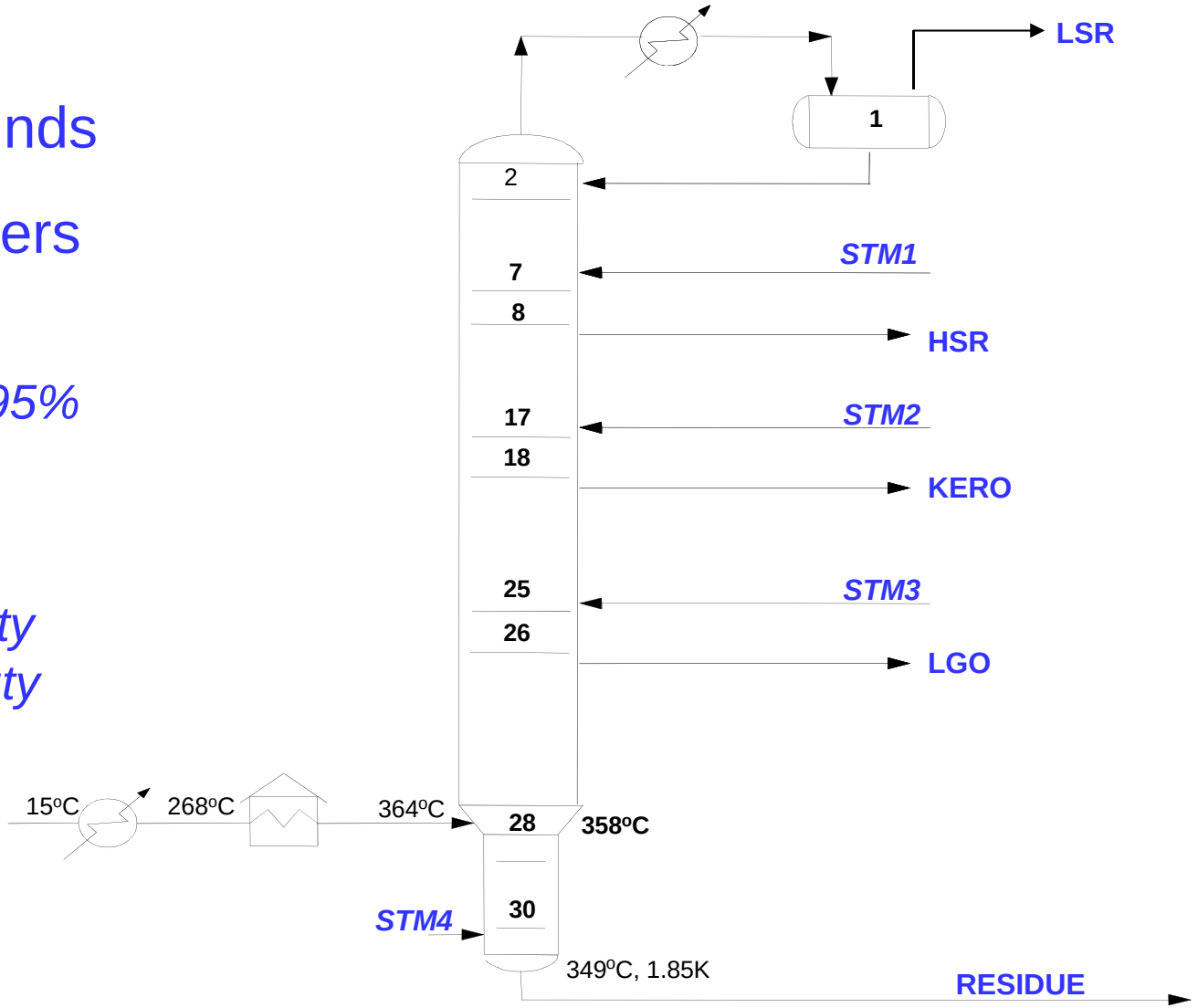


ASTM D86 Curve for RESIDUE



Simplest Crude Column Model

- No Pumparounds
- No Sidestrippers
- Specify
  - *Naphtha D86 95%*
  - *Overflash*
- Vary
  - *Condenser Duty*
  - *Flash Zone Duty*



Part 2 : Simplest crude column model

```
UNIT OPERATIONS DATA
$
 FLASH UID=F01
  FEED ARAB-H,ARAB-L
  PROD M=CRUDE
  ISO TEMP=264,PRES=3.0
$
 COLUMN UID=T01
  PARA TRAY=30,IO=100,DAMP=0.4
  FEED CRUDE,28/STM4,30/STM3,25/STM2,17/STM1,7
  COND TYPE=PART,PRES=2.003
  PROD OVHD(WT)=LSR,147875,WATER=WTR,1,976.5,BTMS=RESI,&
       LDRAW(WT)=10L,8,38375/20L,18,55542/30L,26,159250
  DUTY 1,1/2,28
  VARY DUTY=1,2
  PSPE TOP=2.443,DPCOL=0.44
  ESTI MODEL=REFINERY
  SPEC COLUMN=T01,TRAY=27,PHASE=L,RATE(LV),RATIO,&
        STREAM=CRUDE,VALUE=0.03
  SPEC STREAM=LSR,D86(95),VALUE=153
END
```

File Name = Simple-CDU.inp

Comparison btn Design, Shortcut & *Rigorous(1)*

Design Shortcut *Rigorous (1)*	ASTM D86 5% Temp. (°C)	ASTM D86 50% Temp. (°C)	ASTM D86 95% Temp. (°C)
LSR	71.0	104.0	153
	2.2	111.5	155.0
	2.2	*111.0*	*157.9*
HSR	165.0	183.0	196
	165.0	178.5	196.0
	157.9	*179.5*	*197.2*
KERO	198.0	215.0	235
	198.0	211.1	234.0
	184.2	*215.7*	*239.8*
LGO	246.0	283.0	337
	245.0	281.7	337.0
	227.4	*285.4*	*362.0*
RESIDUE	D1160 5%	D1160 50%	D1160 90%
	368.0	533.0	874.0
	364.0	521.2	811.0
	179	*346*	*586*

GAP : 12, 12, *0*

GAP : 2, 2, *-13*

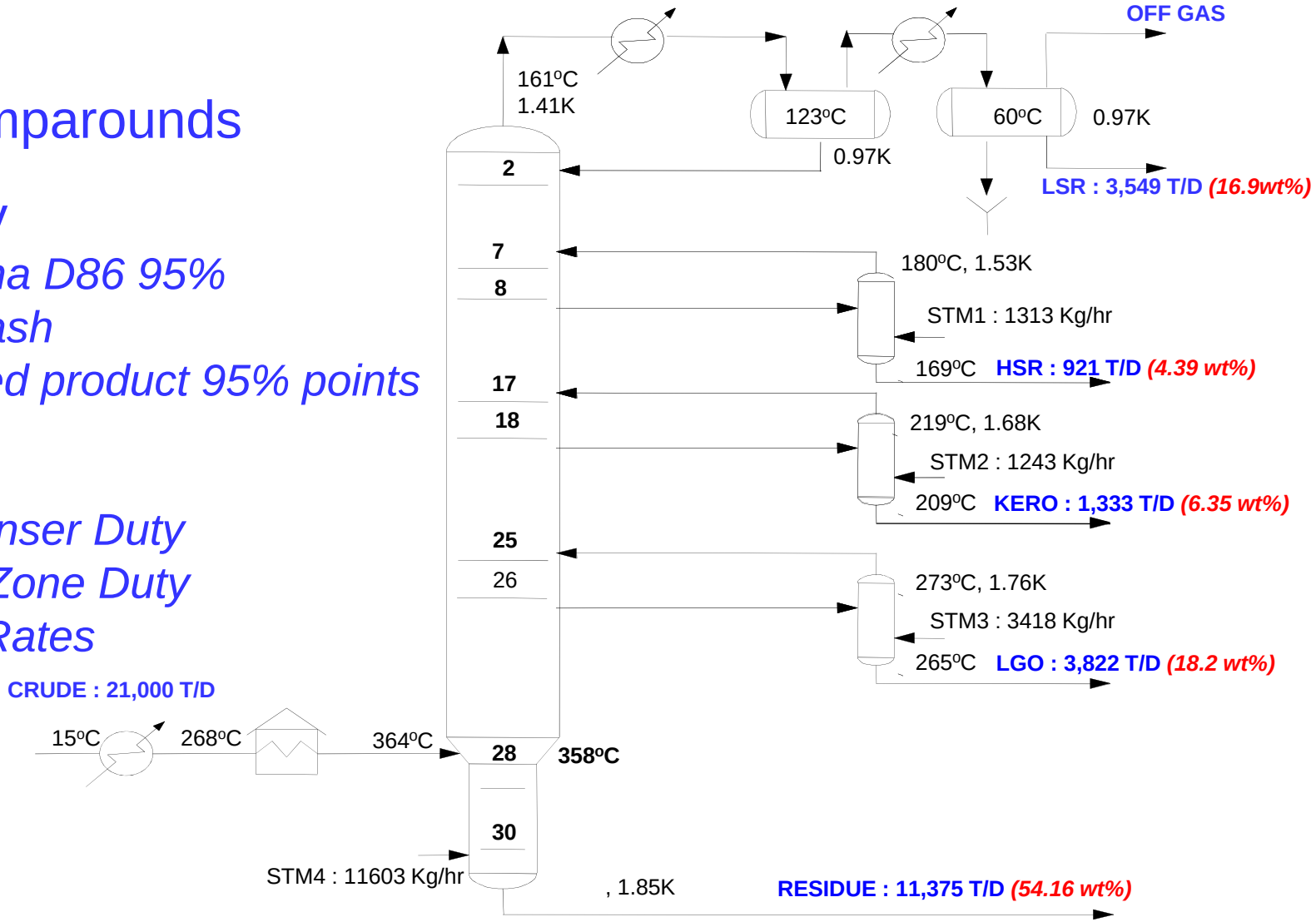
GAP : 11, 11, -12.4

Comparison btn Design, Shortcut & Rigorous(1)

	Design	Shortcut	Rigorous(1)
LSR	3,549	3,644	3,341
HSR	921	953	921
KERO	1,333	1,034	1,333
LGO	3,822	4,155	3,822
RESIDUE	11,375	11,214	11,583

Part 3 : Add Sidestrippers

- No Pumparounds
- Specify
  - *Naphtha D86 95%*
  - *Overflash*
  - *Stripped product 95% points*
- Vary
  - *Condenser Duty*
  - *Flash Zone Duty*
  - *Draw Rates*



Rigorous Simulation (I)

```
COLUMN UID=T01
  PARA TRAY=30,IO=100,DAMP=0.4
  FEED CRUDE,28/STM4,30/10V,7/20V,17/30V,25
  COND TYPE=PART,PRES=2.003
  PROD OVHD(WT)=LSR,147875,WATER=WTR,1,976.5,BTMS=RESI,&
       LDRAW(WT)=10L,8,38375/20L,18,55542/30L,26,159250
  DUTY 1,1/2,28
  VARY DUTY=1,2
  PSPE TOP=2.443,DPCOL=0.44
  ESTI MODEL=REFINERY
$   SPEC TRAY=2,TEMP,VALUE=161
  SPEC COLUMN=T01,TRAY=27,PHASE=L,RATE(LV),RATIO,&
        STREAM=CRUDE,VALUE=0.03        $ OVERFLASH
  SPEC STREAM=LSR,D86(95),VALUE=153    $ LSR D86 95%
```

File Name = NO-PA-CDU-BK10.inp

Rigorous Simulation (II)

```
SIDESTRIPPER UID=S01
  PARA TRAY=2
  FEED 10L,1/STM1,2
  PROD OVHD=10V,BTMS(WT)=HSR,38375
  PSPE TOP=2.563
  SPEC STREAM=HSR,D86(95),VALUE=196   $ HSR D86 95%
  VARY FEED=10L
 SIDESTRIPPER UID=S02
  PARA TRAY=2
  FEED 20L,1/STM2,2
  PROD OVHD=20V,BTMS(WT)=KERO,55542
  PSPE TOP=2.713
  SPEC STREAM=KERO,D86(95),VALUE=235  $ KERO D86 95%
  VARY FEED=20L
 SIDESTRIPPER UID=S03
  PARA TRAY=2
  FEED 30L,1/STM3,2
  PROD OVHD=30V,BTMS(WT)=LGO,159250
  PSPE TOP=2.793
  SPEC STREAM=LGO,D86(95),VALUE=337   $ LGO D86 95%
  VARY FEED=30L
END
```

Examining Simulation Results: U-type

Design U-type-BK10 *U-type-GS*	ASTM D86 5% Temp. (°C)	ASTM D86 50% Temp. (°C)	ASTM D86 95% Temp. (°C)
LSR	71.0	104.0	153
	2.2	111.5	155.0
	24.6	*117.9*	*156.5*
HSR	165.0	183.0	196
	160.4	179.6	196
	161.8	*178.9*	*196*
KERO	198.0	215.0	235
	190.5	213.5	235
	188.0	*212.4*	*235*
LGO	246.0	283.0	337
	236.7	272.0	337
	233.8	*271.1*	*337*
RESIDUE	D1160 5%	D1160 50%	D1160 90%
	368.0	533.0	874.0

GAP : 12, 5.4, 5.3

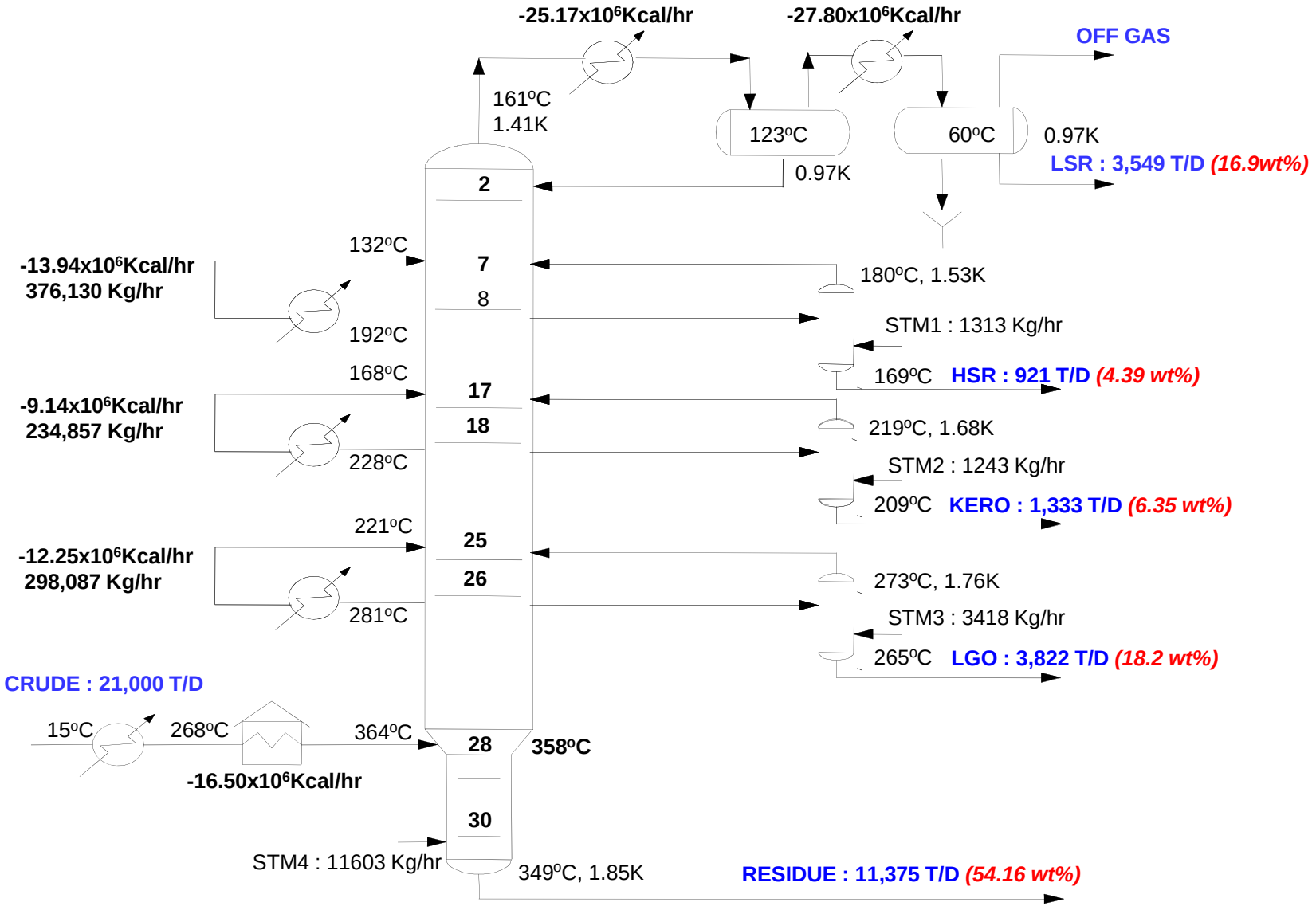
GAP : 2, -5.5, -8

GAP : 11, 1.7, -1.2

Comparison btn Design, Shortcut, U-type-BK10 & U-type-GS

	Side Distillate Flow Rate Comparison			
	Design	Shortcut	U-type-BK10	U-type-GS
LSR	3,549	3,644	3,341	3,851
HSR	921	953	921	905
KERO	1,333	1,034	1,333	1,180
LGO	3,822	4,155	3,822	2,477
RESIDUE	11,375	11,214	11,583	12,587

Part 4 : Add Pumparound Coolers



A-type Simulation (I)

```
COLUMN UID=T01
  PARA TRAY=30,IO=100,DAMP=0.4
  FEED CRUDE,28/STM4,30/10V,7/20V,17/30V,25
  COND TYPE=PART,PRES=2.003
  PROD OVHD(WT)=LSR,147875,WATER=WTR,1,976.5,BTMS=RESI,&
       LDRAW(WT)=10L,8,38375/20L,18,55542/30L,26,159250
  DUTY 1,1/2,28/3,7,-13.94/4,17,-9.14/5,25,-12.25
  PA FROM=8,TO=7,RATE(WT)=376130
  PA FROM=18,TO=17,RATE(WT)=234857
  PA FROM=26,TO=25,RATE(WT)=298087
  VARY DUTY=1,2
  PSPE TOP=2.443,DPCOL=0.44
  ESTI MODEL=REFINERY
  SPEC COLUMN=T01,TRAY=27,PHASE=L,RATE(LV),RATIO,&
        STREAM=CRUDE,VALUE=0.03        $ OVERFLASH
  SPEC STREAM=LSR,D86(95),VALUE=153    $ LSR D86 95%
SIDESTRIPPER UID=S01
  PARA TRAY=2
  FEED 10L,1/STM1,2
  PROD OVHD=10V,BTMS(WT)=HSR,38375
  PSPE TOP=2.563
  SPEC STREAM=HSR,D86(95),VALUE=196    $ HSR D86 95%
  VARY FEED=10L
```

File Name = With-PA-CUD-BK10.inp

A-type Simulation (II)

```
SIDESTRIPPER UID=S02
  PARA TRAY=2
  FEED 20L,1/STM2,2
  PROD OVHD=20V,BTMS(WT)=KERO,55542
  PSPE TOP=2.713
  SPEC STREAM=KERO,D86(95),VALUE=235  $ KERO D86 95%
  VARY FEED=20L
 SIDESTRIPPER UID=S03
  PARA TRAY=2
  FEED 30L,1/STM3,2
  PROD OVHD=30V,BTMS(WT)=LGO,159250
  PSPE TOP=2.793
  SPEC STREAM=LGO,D86(95),VALUE=337   $ LGO D86 95%
  VARY FEED=30L
 FLASH UID=F02
  FEED LSR
  PROD V=OFF-GAS,L=LNAPHTHA
  ISO TEMP=60,PRES=2.003
END
```

Examining Simulation Results: A-type

Design A-type-BK10 *A-type-GS*	ASTM D86 5% Temp. (°C)	ASTM D86 50% Temp. (°C)	ASTM D86 95% Temp. (°C)
LSR	71.0	104.0	153
	2.0	106.2	155.4
	24.5	*111.7*	*157.2*
HSR	165.0	183.0	196
	140.8	172.8	196
	137.0	*170.2*	*196*
KERO	198.0	215.0	235
	178.6	211.4	235
	174.3	*210.0*	*235*
LGO	246.0	283.0	337
	230.3	270.6	337
	225.5	*269.5*	*337*
RESIDUE	D1160 5%	D1160 50%	D1160 90%
	368.0	533.0	874.0

GAP : 12, -14.6, -20.2

GAP : 2, -17.4, *-21.7*

GAP : 11, -4.7, -9.5

Increasing the sidestripper stage number : 3 from 2

```
SIDESTRIPPER UID=S01
  PARA TRAY=3
  FEED 10L,1/STM1,3
  PROD OVHD=10V,BTMS(WT)=HSR,38375
  PSPE TOP=2.563
  SPEC STREAM=HSR,D86(95),VALUE=196   $ HSR D86 95%
  VARY FEED=10L
SIDESTRIPPER UID=S02
  PARA TRAY=3
  FEED 20L,1/STM2,3
  PROD OVHD=20V,BTMS(WT)=KERO,55542
  PSPE TOP=2.713
  SPEC STREAM=KERO,D86(95),VALUE=235  $ KERO D86 95%
  VARY FEED=20L
 SIDESTRIPPER UID=S03
  PARA TRAY=3
  FEED 30L,1/STM3,3
  PROD OVHD=30V,BTMS(WT)=LGO,159250
  PSPE TOP=2.793
  SPEC STREAM=LGO,D86(95),VALUE=337   $ LGO D86 95%
  VARY FEED=30L
END
```

Examining Simulation Results: A-type

Design Side-3-BK10 *Side-4-GS*	ASTM D86 5% Temp. (°C)	ASTM D86 50% Temp. (°C)	ASTM D86 95% Temp. (°C)
LSR	71.0	104.0	153
	2.0	106.3	155.3
	2.0	*106.4*	*155.3*
HSR	165.0	183.0	196
	142.5	173.1	196
	143.5	*173.3*	*196*
KERO	198.0	215.0	235
	180.3	211.5	235
	181.4	*211.6*	*235*
LGO	246.0	283.0	337
	233.7	271.0	337
	235.0	*271.2*	*337*
RESIDUE	D1160 5%	D1160 50%	D1160 90%
	368.0	533.0	874.0

GAP : 12, -12.8, -11.8

GAP : 2, -15.7, *-14.6*

GAP : 11, -1.3, -0

Increasing the flowrate of stripping steam (1)

				STM(KG) / SIDECUT(M3)			
SIDECUT	FLOW (M3/HR)	STM	FLOW (KG/HR)	1	CASE 2	CASE 3	CASE 4
HSR	61.04	STM1	1,313	21.5	24 (1,465)	27 (1,648)	30 (1,831)
KERO	61.58	STM2	1,243	20.2	24 (1,478)	27 (1,663)	30 (1,874)
LGO	129.8	STM3	3,418	26.3	24 (3,115)	27 (3,505)	30 (3,894)
RESID	564.1	STM4	11,603	20.6	24 (13,538)	27 (15,231)	30 (16,923)

CASE	FILE NAME
CASE 2	WITH-PA-CDU-BK10-S2.inp
CASE 3	WITH-PA-CDU-BK10-S3.inp
CASE 4	WITH-PA-CDU-BK10-S4.inp

Examining Simulation Results: Sidestripper = 2 tray

Design Steam-24 Steam-27 Steam-30	ASTM D86 5% Temp. (°C)	ASTM D86 50% Temp. (°C)	ASTM D86 95% Temp. (°C)
LSR	71.0	104.0	153
	2.0	106.5	155.3
	2.0	106.8	155.3
	2.0	107.1	155.3
HSR	165.0	183.0	196
	141.9	173.3	196
	143.2	173.8	196
	144.3	174.3	196
KERO	198.0	215.0	235
	179.6	211.6	235
	180.5	211.7	235
	181.3	211.9	235
LGO	246.0	283.0	337
	229.6	270.6	337
	230.8	270.8	337
	231.9	271.1	337

Increasing the flowrate of stripping steam (2)

				STM(KG) / SIDECUT(M3)			
SIDECUT	FLOW (M3/HR)	STM	FLOW (KG/HR)	1	CASE 2	CASE 3	CASE 4
HSR	60.75	STM1	1,313	21.6	24 (1,458)	27 (1,640)	30 (1,823)
KERO	61.70	STM2	1,243	20.1	24 (1,481)	27 (1,667)	30 (1,851)
LGO	127.80	STM3	3,418	26.7	24 (3,067)	27 (3,451)	30 (3,834)
RESID	564.9	STM4	11,603	20.6	24 (13,558)	27 (15,252)	30 (16,923)

CASE	FILE NAME
CASE 2	WITH-PA3-CDU-BK10-S2.inp
CASE 3	WITH-PA3-CDU-BK10-S3.inp
CASE 4	WITH-PA3-CDU-BK10-S4.inp

Examining Simulation Results: Sidestripper = 3 tray

Design Steam-24 Steam-27 Steam-30	ASTM D86 5% Temp. (°C)	ASTM D86 50% Temp. (°C)	ASTM D86 95% Temp. (°C)
LSR	71.0	104.0	153
	2.0	106.6	155.3
	2.0	106.9	155.3
	2.0	107.2	155.2
HSR	165.0	183.0	196
	143.7	173.6	196
	145.0	174.1	196
	146.3	174.6	196
KERO	198.0	215.0	235
	181.6	211.7	235
	182.5	211.9	235
	183.3	212.0	235
LGO	246.0	283.0	337
	232.9	270.9	337
	233.8	271.1	337
	234.5	271.4	337

Increasing the flowrate of stripping steam (3)

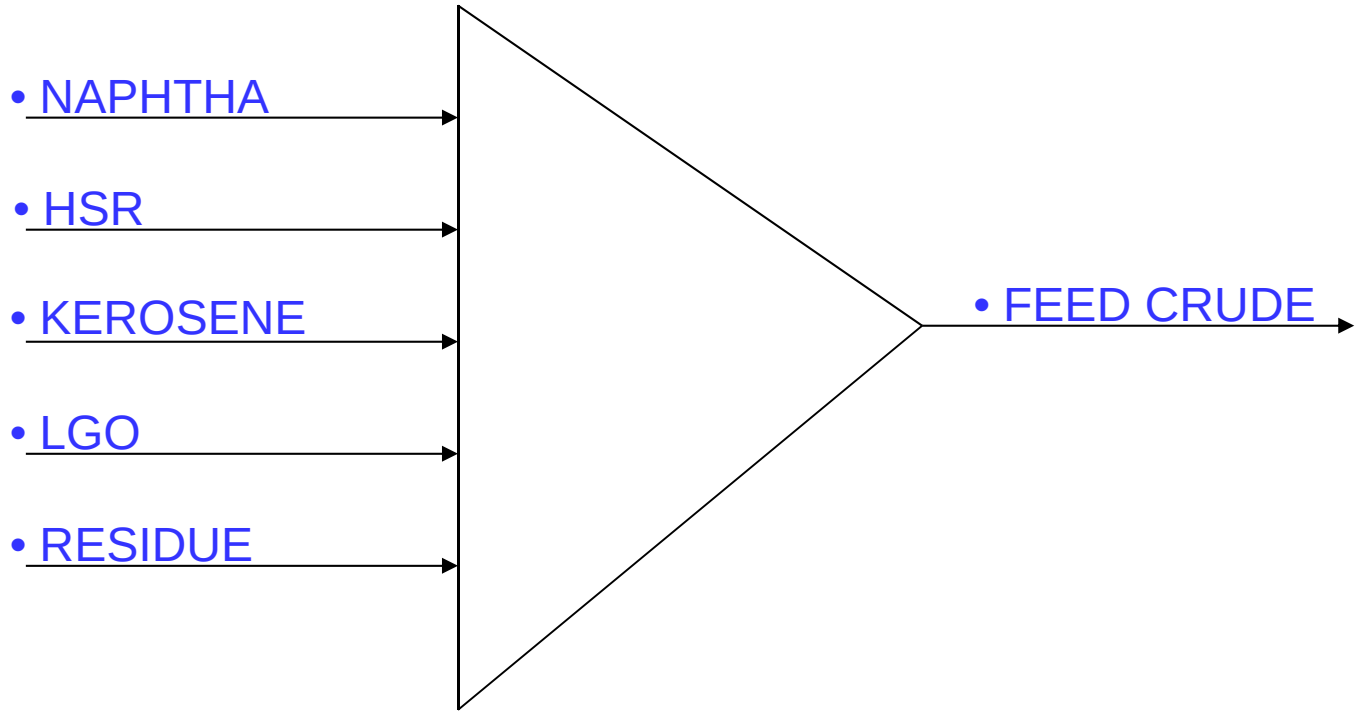
				STM(KG) / SIDECUT(M3)			
SIDECUT	FLOW (M3/HR)	STM	FLOW (KG/HR)	1	CASE 2	CASE 3	CASE 4
HSR	60.62	STM1	1,313	21.7	24 (1,455)	27 (1,637)	30 (1,819)
KERO	61.72	STM2	1,243	20.1	24 (1,481)	27 (1,666)	30 (1,852)
LGO	126.69	STM3	3,418	27.0	24 (3,041)	27 (3,421)	30 (3,801)
RESID	565.3	STM4	11,603	20.5	24 (13,567)	27 (15,263)	30 (16,959)

CASE	FILE NAME
CASE 2	WITH-PA4-CDU-BK10-S2.inp
CASE 3	WITH-PA4-CDU-BK10-S3.inp
CASE 4	WITH-PA4-CDU-BK10-S4.inp

Examining Simulation Results: Sidestripper = 4 tray

Design Steam-24 Steam-27 Steam-30	ASTM D86 5% Temp. (°C)	ASTM D86 50% Temp. (°C)	ASTM D86 95% Temp. (°C)
LSR	71.0	104.0	153
	2.0	106.7	155.3
	2.0	107.0	155.3
	2.0	107.3	155.2
HSR	165.0	183.0	196
	144.7	173.8	196
	146.2	174.3	196
	147.6	174.7	196
KERO	198.0	215.0	235
	182.7	211.8	235
	183.7	212.0	235
	184.6	212.1	235
LGO	246.0	283.0	337
	234.1	271.1	337
	234.9	271.3	337
	235.7	271.6	337

Part 5 : Blend Products to make the Feed



Sidecut Properties

Comp, wt%	OFF GAS	D86	NAPH	HSR	KERO	LGO	D1160 (ATM)	RESID
H2O	0.00	IBP	69	137	168	218	IBP	*319*
C1	0.05	5 %	71	165	198	246	5 %	*368*
C2	1.50	10 %	74	172	203	254	10 %	*381*
C3	0.95	30 %	88	179	210	268	30 %	*454*
C4	4.60	50 %	104	183	215	283	50 %	*533*
Total	7.90	70 %	122	187	221	301	70 %	*684*
		90 %	146	193	229	328	90 %	*874*
		95 %	153	196	235	337	95 %	-
		EP	162	204	251	378	EP	-
Sp. Gr.			0.7037	0.7826	0.8034	0.8456		*0.9713*
WT %			16.9	4.39	6.35	18.20		*54.16*

Part 5: Shortcut Simulation

```
TITLE PROB=SHORT,PROJECT=FPCC,USER=DR_JHCHO
$$ SHORTCUT MODEL FOR CRUDE UNIT TO CHECK PRODUCT RATES $$
 DIME METRIC, LIQV=BBL
 PRINT STREAM=PART, TBP, INPUT=NONE
COMP DATA
 LIBID 1,H2O/2,C2/3,C3/4,IC4/5,NC4
ASSAY CONV=API63
THERMO DATA
 METHODS SYSTEM=BK10
STREAM DATA
$
 PROP STRM=NAPH,TEMP=15,PRES=5.033,RATE(WT)=147875, ASSAY=LV
  SPGR STREAM=NAPH, AVG=0.7037
  D86 STREAM=NAPH, DATA=10,74/30,88/50,104/70,122/&
          90,146/95,153/100,162
  LIGHTEND STREAM=NAPH, PERCENT(WT)=7.1,&
          COMP(LV)=2,0.05/3,1.5/4,0.95/5,4.6,NORM
$
 PROP STRM=HSR,TEMP=15,PRES=5.033,RATE(WT)=38413, ASSAY=LV
  SPGR STREAM=HSR, AVG=0.7836
  D86 STREAM=HSR, DATA=0,138/5,165/10,172/30,179/50,183/70,187/&
          90,193/95,196/100,204
```

File Name : Short-BK10.bkp

```
PROP STRM=KERO,TEMP=15,PRES=5.033,RATE(WT)=55563, ASSAY=LV
 SPGR STREAM=KERO, AVG=0.8034
 D86 STREAM=KERO, DATA=0,168/5,198/10,203/30,210/50,215/70,221/&
         90,229/95,235/100,251
PROP STRM=LGO,TEMP=15,PRES=5.033,RATE(WT)=159250, ASSAY=LV
 SPGR STREAM=LGO, AVG=0.8456
 D86 STREAM=LGO, DATA=0,218/5,246/10,254/30,268/50,283/70,301/&
         90,328/95,337/100,378
PROP STRM=RESID,TEMP=15,PRES=5.033,RATE(WT)=473899, ASSAY=LV
 SPGR STREAM=RESID, AVG=0.9713
 D1160 STREAM=RESID, DATA=0,319/5,368/10,381/30,454/50,533/70,684/&
         90,874
PROP STRE=STM1, PRES=4.533, PHASE=V, COMP(WT)=1,1313
PROP STRE=STM2, PRES=4.533, PHASE=V, COMP(WT)=1,1243
PROP STRE=STM3, PRES=4.533, PHASE=V, COMP(WT)=1,3418
PROP STRE=STM4, PRES=45.33, PHASE=V, COMP(WT)=1,11603
OUTPUT FORMAT=REFINE
```

```
UNIT OPERATIONS DATA
 SHORTCUT UID=S01
  FEED NAPH,HSR,KERO,LGO,RESID,STM1,STM2,STM3,STM4
  PROD STREAM=LSRP,PHASE=M,PRES=2.443,CUTP(WT)=16.9
  PROD STREAM=HSRP,PHASE=L,PRES=2.563,CUTP(WT)=21.29
  PROD STREAM=KERP,PHASE=L,PRES=2.713,CUTP(WT)=27.64
  PROD STREAM=LGOP,PHASE=L,PRES=2.793,CUTP(WT)=45.84
  PROD STREAM=RESP,PHASE=L,PRES=2.85
  COND TYPE=MIXED,TEMP=123
  EVALUATE MODEL=REFINE
  SPEC STREAM=LSRP,D86(95),VALUE=153
  SPEC STREAM=HSRP,D86(5),MINUS,STREAM=LSRP,D86(95),VALUE=12
  SPEC STREAM=HSRP,D86(95),VALUE=196
  SPEC STREAM=KERP,D86(5),MINUS,STREAM=HSRP,D86(95),VALUE=2
  SPEC STREAM=KERP,D86(95),VALUE=235
  SPEC STREAM=LGOP,D86(5),MINUS,STREAM=KERP,D86(95),VALUE=11
  SPEC STREAM=LGOP,D86(95),VALUE=337
  SPEC STREAM=RESP,RATE(WT),VALUE=473958
 FLASH UID=F01
  FEED LSRP
  PROD V=VLSR,L=LLSR
  ISO TEMP=123,PRES=2.003
END
```

		TOTAL STREAM RATES					
STREAM + PHASE		MOLES KG-MOL/HR	WEIGHT KG/HR	LIQUID VOL BBL/HR	NORM VAPOR(1) M3/HR	SECTION	NUM TRAYS
LSRP	M	2476.76	163394.87	1414.45	55514.09	1	**5.38**
HSRP	L	272.16	39702.12	322.00	6100.16	2	**7.19**
KERP	L	305.78	51593.78	404.72	6853.78	3	**5.08**
LGOP	L	716.74	163928.31	1222.79	16065.08	4	**3.86**
RESP	L	859.14	473957.84	3071.43	19256.75		
TOTALS		4630.58	892576.92	6435.39	103789.85		**21.51**