

REFERENCES

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APPENDICES

Appendix A Simulation data to keyword for light crude.

\$ Generated by PRO/II Keyword Generation System <version 5.61>

\$ Generated on: Sat Mar 27 19:58:29 2004

TITLE

TOLERANCE STREAM=0.001

DIMENSION SI, TEMP=C, ENERGY=KWH, STDTEMP=0, STDPRES=101.325

SEQUENCE SIMSCI

CALCULATION RVPBASIS=APIN, TVP=37.778, RECYCLE=ALL

COMPONENT DATA

LIBID

1,ETHANE/2,PROPANE/3,IBUTANE/4,BUTANE/5,IPENTANE/6,PENTANE/ &
7,H2O

THERMODYNAMIC DATA

METHOD SYSTEM=GS, SET=GS01, DEFAULT

STREAM DATA

PROPERTY STREAM=CRUDE, TEMPERATURE=21.111, PRESSURE=446.06,
PHASE=M, &

RATE(LV)=794.999, ASSAY=LV

TBP STREAM=CRUDE, DATA=5,45/10,82/30,186/50,281/70,382/90,552, &
TEMP=C

API STREAM=CRUDE, AVERAGE=36

LIGHTEND STREAM=CRUDE,

COMPOSITION(M)=1,0.13/2,0.78/3,0.49/4,1.36/ &
5,1.05/6,1.3, MATCH

PROPERTY STREAM=WATER, TEMPERATURE=21.111, PRESSURE=446.06,
PHASE=M, &

RATE(M)=4535.93, COMPOSITION(M)=7,1

PROPERTY STREAM=RSTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=6020.06, COMPOSITION(M)=7,1

PROPERTY STREAM=KSTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=6673, COMPOSITION(M)=7,1

PROPERTY STREAM=DSTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=1991, COMPOSITION(M)=7,1

PROPERTY STREAM=ASTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=3452.15, COMPOSITION(M)=7,1

PROPERTY STREAM=S1, REFSTREAM=AGO

PROPERTY STREAM=S3, REFSTREAM=DIESEL

PROPERTY STREAM=S5, REFSTREAM=KEROSENE

PROPERTY STREAM=S7, REFSTREAM=SW
 PROPERTY STREAM=S9, REFSTREAM=NAPHTHA
 PROPERTY STREAM=S11, REFSTREAM=COND
 PROPERTY STREAM=S13, REFSTREAM=RESIDUE
 PROPERTY STREAM=S15, REFSTREAM=PA1
 PROPERTY STREAM=S17, REFSTREAM=PA2
 PROPERTY STREAM=S19, REFSTREAM=PA3
 UNIT OPERATIONS
 MIXER UID=M1
 FEED CRUDE,WATER
 PRODUCT M=MIXED
 HX UID=E1
 COLD FEED=MIXED, M=HEATED
 OPER CTEMP=104.44
 FLASH UID=F1
 FEED HEATED
 PRODUCT W=SW, V=DESALTED
 ADIABATIC
 HX UID=E7
 HOT FEED=S7, M=S8
 OPER HTEMP=21.111
 HX UID=E2
 COLD FEED=DESALTED, M=HDESALTED, DP=34.474
 OPER CTEMP=204.44
 HX UID=E3
 COLD FEED=HDESALTED, M=FEEDCRUDE, DP=206.84
 OPER CTEMP=360
 COLUMN UID=T1
 PARAMETER TRAY=34,IO
 FEED
 FEEDCRUDE,29/KTURN,8/DTURN,15/ATURN,24/RSTEAM,34,SEPARATE
 PRODUCT OVHD(LV)=NAPHTHA,250, WATER(M)=DECANTED,1, &
 LDRAW(LV)=KDRAWN,9,144, LDRAW(LV)=DDRAWN,16,69.9998,
 &
 LDRAW(LV)=ADRAWN,25,121, BTMS(LV)=RESIDUE,211, &
 SUPERSEDE=ON
 CONDENSER TYPE=TFIX, TEMPERATURE=43.333
 DUTY 1,1/2,2,-0.021/3,10,-0.038/4,17,-0.005
 PA FROM=4, TO=2, PHASE=L, TEMP=104.444
 PA FROM=12, TO=10, PHASE=L, TEMP=171.111
 PA FROM=19, TO=17, PHASE=L, TEMP=232.222
 PRINT PROPTABLE=PART
 ESTIMATE MODEL=REFINING
 PRESSURE 1,206.815/2,210.262/34,279.21
 SPEC STREAM=NAPHTHA, D86(95,C), VALUE=182
 SPEC STREAM=KEROSENE, D86(95,C), VALUE=271
 SPEC STREAM=DIESEL, D86(95,C), VALUE=327

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SPEC TRAY=28, RATE(LV,BBL/H), PHASE=L, WET, DIVIDE, &
    STREAM=FEEDCRUDE, RATE(LV,BBL/H), TOTAL, WET, &
    VALUE=0.03
VARY DUTY=1
VARY DRAW=KDRAWN,DDRAWN,ADRAWN
TFLOW TOT(V)=COND,2, PA(L)=PA1,4,2/PA2,12,10/PA3,19,17
SIDESTRIPPER UID=SS1
    PARAMETER TRAY=4,IO
    FEED KDRAWN,1/KSTEAM,4
    PRODUCT OVHD(M)=KTURN, BTMS(LV)=KEROSENE,144
    PSPEC PTOP=218.54
    PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS2
    PARAMETER TRAY=4,IO
    FEED DDRAWN,1/DSTEAM,4
    PRODUCT OVHD(M)=DTURN, BTMS(LV)=DIESEL,69.9998
    PSPEC PTOP=239.22
    PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS3
    PARAMETER TRAY=4,IO
    FEED ADRAWN,1/ASTEAM,4
    PRODUCT OVHD(M)=ATURN, BTMS(LV)=AGO,121
    PSPEC PTOP=253.01
    PRINT PROPTABLE=PART
CALCULATOR UID=CA5
    DEFINE P(1) AS STREAM=PA1, TEMPERATURE(C)
    DEFINE P(2) AS COLUMN=T1, DUTY(3,WATT)
    DEFINE P(3) AS STREAM=PA2, TEMPERATURE(C)
    DEFINE P(4) AS COLUMN=T1, DUTY(4,WATT)
    DEFINE P(5) AS STREAM=PA3, TEMPERATURE(C)
    PROCEDURE
        R1=P1
        R2=P2
        R3=P3
        R4=P4
        R5=P5
    RETURN
CALCULATOR UID=CA4
    DEFINE P(1) AS STREAM=RESIDUE, TEMPERATURE(C)
    DEFINE P(2) AS COLUMN=T1, DUTY(1,KW)
    DEFINE P(3) AS COLUMN=T1, TRAY=2, TEMPERATURE(C)
    DEFINE P(4) AS COLUMN=T1, TRAY=29, TEMPERATURE(C)
    DEFINE P(5) AS COLUMN=T1, DUTY(2,WATT)
    PROCEDURE
        R1=P1
        R2=P2
        R3=P3

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R4=P4
R5=P5
RETURN
CALCULATOR UID=CA3
  DEFINE P(1) AS STREAM=DIESEL, D86(5,C), MINUS,
STREAM=KEROSENE, &
  D86(95,C)
  DEFINE P(2) AS STREAM=AGO, D86(5,C), MINUS, STREAM=DIESEL, &
  D86(95,C)
  DEFINE P(3) AS STREAM=KEROSENE, TEMPERATURE(C)
  DEFINE P(4) AS STREAM=DIESEL, TEMPERATURE(C)
  DEFINE P(5) AS STREAM=AGO, TEMPERATURE(C)
  PROCEDURE
    R1=P1
    R2=P2
    R3=P3
    R4=P4
    R5=P5
    RETURN
CALCULATOR UID=CA2
  DEFINE P(1) AS STREAM=KSTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
  STREAM=KEROSENE, RATE(LV,BBL/H),TOTAL,WET
  DEFINE P(2) AS STREAM=DSTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
  STREAM=DIESEL, RATE(LV,BBL/H),TOTAL,WET
  DEFINE P(3) AS STREAM=ASTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
  STREAM=AGO, RATE(LV,BBL/H),TOTAL,WET
  DEFINE P(4) AS STREAM=RSTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
  STREAM=RESIDUE, RATE(LV,BBL/H),TOTAL,WET
  DEFINE P(5) AS STREAM=KEROSENE, D86(5,C), MINUS, &
  STREAM=NAPHTHA, D86(95,C)
  PROCEDURE
    R1=P1
    R2=P2
    R3=P3
    R4=P4
    R5=P5
    RETURN
CALCULATOR UID=CA1
  DEFINE P(1) AS STREAM=NAPHTHA, RATE(LV,M3/H),TOTAL,WET
  DEFINE P(2) AS STREAM=KEROSENE, RATE(LV,M3/H),TOTAL,WET
  DEFINE P(3) AS STREAM=DIESEL, RATE(LV,M3/H),TOTAL,WET
  DEFINE P(4) AS STREAM=AGO, RATE(LV,M3/H),TOTAL,WET
  DEFINE P(5) AS STREAM=RESIDUE, RATE(LV,M3/H),TOTAL,WET

```

```
PROCEDURE
  R1=P1
  R2=P2
  R3=P3
  R4=P4
  R5=P5
  RETURN
HX UID=E13
  HOT FEED=S19, M=S20
  OPER HTEMP=232.22
HX UID=E12
  HOT FEED=S17, M=S18
  OPER HTEMP=171.11
HX UID=E11
  HOT FEED=S15, M=S16
  OPER HTEMP=104.44
HX UID=E10
  HOT FEED=S13, M=S14
  OPER HTEMP=260
HX UID=E9
  HOT FEED=S11, M=S12
  OPER HTEMP=43.333
HX UID=E8
  HOT FEED=S9, M=S10
  OPER HTEMP=21.111
HX UID=E6
  HOT FEED=S5, M=S6
  OPER HTEMP=21.111
HX UID=E5
  HOT FEED=S3, M=S4
  OPER HTEMP=21.111
HX UID=E4
  HOT FEED=S1, M=S2
  OPER HTEMP=21.111
END
```

Appendix B Simulation data to keyword for intermediate crude.

\$ Generated by PRO/II Keyword Generation System <version 5.61>
 \$ Generated on: Sat Mar 27 20:13:02 2004
 TITLE
 TOLERANCE STREAM=0.001
 DIMENSION SI, TEMP=C, ENERGY=KWH, STDTEMP=0, STDPRES=101.325
 SEQUENCE SIMSCI
 CALCULATION RVPBASIS=APIN, TVP=37.778, RECYCLE=ALL
 COMPONENT DATA
 LIBID
 1,ETHANE/2,PROPANE/3,IBUTANE/4,BUTANE/5,IPENTANE/6,PENTANE/ &
 7,H2O
 THERMODYNAMIC DATA
 METHOD SYSTEM=GS, SET=GS01, DEFAULT
 STREAM DATA
 PROPERTY STREAM=CRUDE, TEMPERATURE=21.111, PRESSURE=446.06,
 PHASE=M, &
 RATE(LV)=794.999, ASSAY=LV
 TBP STREAM=CRUDE, DATA=5,94/10,131/30,265/50,380/70,506/90,670, &
 TEMP=C
 API STREAM=CRUDE, AVERAGE=27.7
 LIGHTEND STREAM=CRUDE, COMPOSITION(M)=1,0.1/2,0.3/3,0.2/4,0.7, &
 MATCH
 PROPERTY STREAM=WATER, TEMPERATURE=21.111, PRESSURE=446.06,
 PHASE=M, &
 RATE(M)=4535.93, COMPOSITION(M)=7,1
 PROPERTY STREAM=RSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=12173, COMPOSITION(M)=7,1
 PROPERTY STREAM=KSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=2707.17, COMPOSITION(M)=7,1
 PROPERTY STREAM=DSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=1731, COMPOSITION(M)=7,1
 PROPERTY STREAM=ASTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=1672.89, COMPOSITION(M)=7,1
 PROPERTY STREAM=S1, REFSTREAM=AGO
 PROPERTY STREAM=S3, REFSTREAM=DIESEL
 PROPERTY STREAM=S5, REFSTREAM=KEROSENE
 PROPERTY STREAM=S7, REFSTREAM=SW
 PROPERTY STREAM=S9, REFSTREAM=NAPHTHA
 PROPERTY STREAM=S11, REFSTREAM=COND
 PROPERTY STREAM=S13, REFSTREAM=RESIDUE

PROPERTY STREAM=S15, REFSTREAM=PA1
 PROPERTY STREAM=S17, REFSTREAM=PA2
 PROPERTY STREAM=S19, REFSTREAM=PA3
 UNIT OPERATIONS
 MIXER UID=M1
 FEED CRUDE,WATER
 PRODUCT M=MIXED
 HX UID=E1
 COLD FEED=MIXED, M=HEATED
 OPER CTEMP=104.44
 FLASH UID=F1
 FEED HEATED
 PRODUCT W=SW, V=DESALTED
 ADIABATIC
 HX UID=E28
 HOT FEED=S7, M=S8
 OPER HTEMP=21.111
 HX UID=E2
 COLD FEED=DESALTED, M=HDESALTED, DP=34.474
 OPER CTEMP=204.44
 HX UID=E3
 COLD FEED=HDESALTED, M=FEEDCRUDE, DP=206.84
 OPER CTEMP=360
 COLUMN UID=T1
 PARAMETER TRAY=34,IO
 FEED
 FEEDCRUDE,29/KTURN,8/DTURN,15/ATURN,24/RSTEAM,34,SEPARATE
 PRODUCT OVHD(LV)=NAPHTHA,154.5, WATER(M)=DECANTED,1, &
 LDRAW(LV)=KDRAWN,9,94.8892, LDRAW(LV)=DDRAWN,16, &
 60.673, LDRAW(LV)=ADRAWN,25,58.6361, BTMS(LV)=RESIDUE, &
 426.679, SUPERSEDE=ON
 CONDENSER TYPE=TFIX, TEMPERATURE=43.333
 DUTY 1,1/2,2,-0.025/3,10,-0.013/4,17,-0.002
 PA FROM=4, TO=2, PHASE=L, TEMP=104.444
 PA FROM=12, TO=10, PHASE=L, TEMP=171.111
 PA FROM=19, TO=17, PHASE=L, TEMP=232.222
 PRINT PROPTABLE=PART
 ESTIMATE MODEL=REFINING
 PRESSURE 1,206.815/2,210.262/34,279.21
 SPEC STREAM=NAPHTHA, D86(95,C), VALUE=182
 SPEC STREAM=KEROSENE, D86(95,C), VALUE=271
 SPEC STREAM=DIESEL, D86(95,C), VALUE=327
 SPEC TRAY=28, RATE(LV,BBL/H), PHASE=L, WET, DIVIDE, &
 STREAM=FEEDCRUDE, RATE(LV,BBL/H),TOTAL, WET, &
 VALUE=0.03
 VARY DUTY=1
 VARY DRAW=KDRAWN,DDRAWN,ADRAWN

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TFLOW TOT(V)=COND,2, PA(L)=PA3,19,17/PA2,12,10/PA1,4,2
SIDESTRIPPER UID=SS1
  PARAMETER TRAY=4,IO
  FEED KDRAWN,1/KSTEAM,4
  PRODUCT OVHD(M)=KTURN, BTMS(LV)=KEROSENE,144
  PSPEC PTOP=218.54
  PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS2
  PARAMETER TRAY=4,IO
  FEED DDRAWN,1/DSTEAM,4
  PRODUCT OVHD(M)=DTURN, BTMS(LV)=DIESEL,69.9998
  PSPEC PTOP=239.22
  PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS3
  PARAMETER TRAY=4,IO
  FEED ADRAWN,1/ASTEAM,4
  PRODUCT OVHD(M)=ATURN, BTMS(LV)=AGO,121
  PSPEC PTOP=253.01
  PRINT PROPTABLE=PART
CALCULATOR UID=CA5
  DEFINE P(1) AS STREAM=PA1, TEMPERATURE(C)
  DEFINE P(2) AS COLUMN=T1, DUTY(3,WATT)
  DEFINE P(3) AS STREAM=PA2, TEMPERATURE(C)
  DEFINE P(4) AS COLUMN=T1, DUTY(4,WATT)
  DEFINE P(5) AS STREAM=PA3, TEMPERATURE(C)
  PROCEDURE
    R1=P1
    R2=P2
    R3=P3
    R4=P4
    R5=P5
  RETURN
CALCULATOR UID=CA4
  DEFINE P(1) AS STREAM=RESIDUE, TEMPERATURE(C)
  DEFINE P(2) AS COLUMN=T1, DUTY(1,KW)
  DEFINE P(3) AS COLUMN=T1, TRAY=2, TEMPERATURE(C)
  DEFINE P(4) AS COLUMN=T1, TRAY=29, TEMPERATURE(C)
  DEFINE P(5) AS COLUMN=T1, DUTY(2,WATT)
  PROCEDURE
    R1=P1
    R2=P2
    R3=P3
    R4=P4
    R5=P5
  RETURN
CALCULATOR UID=CA3

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DEFINE P(1) AS STREAM=DIESEL, D86(5,C), MINUS,
STREAM=KEROSENE, &
    D86(95,C)
DEFINE P(2) AS STREAM=AGO, D86(5,C), MINUS, STREAM=DIESEL, &
    D86(95,C)
DEFINE P(3) AS STREAM=KEROSENE, TEMPERATURE(C)
DEFINE P(4) AS STREAM=DIESEL, TEMPERATURE(C)
DEFINE P(5) AS STREAM=AGO, TEMPERATURE(C)
PROCEDURE
R1=P1
R2=P2
R3=P3
R4=P4
R5=P5
RETURN
CALCULATOR UID=CA2
DEFINE P(1) AS STREAM=KSTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
    STREAM=KEROSENE, RATE(LV,BBL/H),TOTAL,WET
DEFINE P(2) AS STREAM=DSTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
    STREAM=DIESEL, RATE(LV,BBL/H),TOTAL,WET
DEFINE P(3) AS STREAM=ASTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
    STREAM=AGO, RATE(LV,BBL/H),TOTAL,WET
DEFINE P(4) AS STREAM=RSTEAM, RATE(WT,LB/H),TOTAL,WET,
DIVIDE, &
    STREAM=RESIDUE, RATE(LV,BBL/H),TOTAL,WET
DEFINE P(5) AS STREAM=KEROSENE, D86(5,C), MINUS, &
    STREAM=NAPHTHA, D86(95,C)
PROCEDURE
R1=P1
R2=P2
R3=P3
R4=P4
R5=P5
RETURN
CALCULATOR UID=CA1
DEFINE P(1) AS STREAM=NAPHTHA, RATE(LV,M3/H),TOTAL,WET
DEFINE P(2) AS STREAM=KEROSENE, RATE(LV,M3/H),TOTAL,WET
DEFINE P(3) AS STREAM=DIESEL, RATE(LV,M3/H),TOTAL,WET
DEFINE P(4) AS STREAM=AGO, RATE(LV,M3/H),TOTAL,WET
DEFINE P(5) AS STREAM=RESIDUE, RATE(LV,M3/H),TOTAL,WET
PROCEDURE
R1=P1
R2=P2
R3=P3

```

```
R4=P4
R5=P5
RETURN
HX UID=E6
  HOT FEED=S19, M=S20
  OPER HTEMP=232.22
HX UID=E5
  HOT FEED=S17, M=S18
  OPER HTEMP=171.11
HX UID=E4
  HOT FEED=S15, M=S16
  OPER HTEMP=104.44
HX UID=E31
  HOT FEED=S13, M=S14
  OPER HTEMP=260
HX UID=E30
  HOT FEED=S11, M=S12
  OPER HTEMP=43.333
HX UID=E29
  HOT FEED=S9, M=S10
  OPER HTEMP=21.111
HX UID=E27
  HOT FEED=S5, M=S6
  OPER HTEMP=21.111
HX UID=E26
  HOT FEED=S3, M=S4
  OPER HTEMP=21.111
HX UID=E25
  HOT FEED=S1, M=S2
  OPER HTEMP=21.111
END
```

Appendix C Simulation data to keyword for heavy crude.

\$ Generated by PRO/II Keyword Generation System <version 5.61>
 \$ Generated on: Sat Mar 27 20:16:04 2004
 TITLE
 TOLERANCE STREAM=0.001
 DIMENSION SI, TEMP=C, ENERGY=KWH, STDTEMP=0, STDPRES=101.325
 SEQUENCE SIMSCI
 CALCULATION RVPBASIS=APIN, TVP=37.778, RECYCLE=ALL
 COMPONENT DATA
 LIBID
 1,ETHANE/2,PROPANE/3,IBUTANE/4,BUTANE/5,IPENTANE/6,PENTANE/ &
 7,H2O
 THERMODYNAMIC DATA
 METHOD SYSTEM=GS, SET=GS01, DEFAULT
 STREAM DATA
 PROPERTY STREAM=CRUDE, TEMPERATURE=21.111, PRESSURE=446.06,
 PHASE=M, &
 RATE(LV)=794.999, ASSAY=LV
 TBP STREAM=CRUDE, DATA=5,133/10,237/30,344/50,482/70,640, TEMP=C
 API STREAM=CRUDE, AVERAGE=20
 LIGHTEND STREAM=CRUDE,
 COMPOSITION(M)=2,0.04/3,0.04/4,0.11/5,0.14/ &
 6,0.16, MATCH
 PROPERTY STREAM=WATER, TEMPERATURE=21.111, PRESSURE=446.06,
 PHASE=M, &
 RATE(M)=4535.93, COMPOSITION(M)=7,1
 PROPERTY STREAM=RSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=17284.1, COMPOSITION(M)=7,1
 PROPERTY STREAM=KSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=1392.26, COMPOSITION(M)=7,1
 PROPERTY STREAM=DSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=1705.23, COMPOSITION(M)=7,1
 PROPERTY STREAM=ASTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=2373.78, COMPOSITION(M)=7,1
 PROPERTY STREAM=S1, REFSTREAM=AGO
 PROPERTY STREAM=S3, REFSTREAM=DIESEL
 PROPERTY STREAM=S5, REFSTREAM=KEROSENE
 PROPERTY STREAM=S7, REFSTREAM=SW
 PROPERTY STREAM=S9, REFSTREAM=NAPHTHA
 PROPERTY STREAM=S11, REFSTREAM=COND
 PROPERTY STREAM=S13, REFSTREAM=RESIDUE

PROPERTY STREAM=S15, REFSTREAM=PA1
 PROPERTY STREAM=S17, REFSTREAM=PA2
 PROPERTY STREAM=S19, REFSTREAM=PA3
 UNIT OPERATIONS
 MIXER UID=M1
 FEED CRUDE,WATER
 PRODUCT M=MIXED
 HX UID=E1
 COLD FEED=MIXED, M=HEATED
 OPER CTEMP=104.44
 FLASH UID=F1
 FEED HEATED
 PRODUCT W=SW, V=DESALTED
 ADIABATIC
 HX UID=E7
 HOT FEED=S7, M=S8
 OPER HTEMP=21.111
 HX UID=E2
 COLD FEED=DESALTED, M=HDESALTED, DP=34.474
 OPER CTEMP=204.44
 HX UID=E3
 COLD FEED=HDESALTED, M=FEEDCRUDE, DP=206.84
 OPER CTEMP=360
 COLUMN UID=T1
 PARAMETER TRAY=34,IO
 FEED
 FEEDCRUDE,29/KTURN,8/DTURN,15/ATURN,24/RSTEAM 34,SEPARATE
 PRODUCT OVHD(LV)=NAPHTHA,56.4674, WATER(M)=DECANTED,1, &
 LDRAW(LV)=KDRAWN,9,48.7994, LDRAW(LV)=DDRAWN,16, &
 59.7218, LDRAW(LV)=ADRAWN,25,24.5364, &
 BTMS(LV)=RESIDUE,605.819, SUPERSEDE=ON
 CONDENSER TYPE=TFIX, TEMPERATURE=21.111
 DUTY 1,1/2,2,-0.018/3,10,-0.009/4,17,-0.001
 PA FROM=4, TO=2, PHASE=L, TEMP=104.444
 PA FROM=12, TO=10, PHASE=L, TEMP=171.111
 PA FROM=19, TO=17, PHASE=L, TEMP=232.222
 PRINT PROPTABLE=PART
 ESTIMATE MODEL=REFINING
 PRESSURE 1,206.815/2,210.262/34,279.21
 SPEC STREAM=NAPHTHA, D86(95,C), VALUE=182
 SPEC STREAM=KEROSENE, D86(95,C), VALUE=271
 SPEC STREAM=DIESEL, D86(95,C), VALUE=327
 SPEC TRAY=28, RATE(LV,BBL/H), PHASE=L, WET, DIVIDE, &
 STREAM=FEEDCRUDE, RATE(LV,BBL/H),TOTAL, WET, &
 VALUE=0.03
 VARY DUTY=1
 VARY DRAW=KDRAWN,DDRAWN,ADRAWN

```

    TFLOW TOT(V)=COND,2, PA(L)=PA3,19,17/PA2,12,10/PA1,4,2
SIDESTRIPPER UID=SS1
    PARAMETER TRAY=4,IO
    FEED KDRAWN,1/KSTEAM,4
    PRODUCT OVHD(M)=KTURN, BTMS(LV)=KEROSENE,144
    PSPEC PTOP=218.54
    PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS2
    PARAMETER TRAY=4,IO
    FEED DDRAWN,1/DSTEAM,4
    PRODUCT OVHD(M)=DTURN, BTMS(LV)=DIESEL,69.9998
    PSPEC PTOP=239.22
    PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS3
    PARAMETER TRAY=4,IO
    FEED ADRAWN,1/ASTEAM,4
    PRODUCT OVHD(M)=ATURN, BTMS(LV)=AGO,121
    PSPEC PTOP=253.01
    PRINT PROPTABLE=PART
CALCULATOR UID=CA5
    DEFINE P(1) AS STREAM=PA1, TEMPERATURE(C)
    DEFINE P(2) AS COLUMN=T1, DUTY(3,WATT)
    DEFINE P(3) AS STREAM=PA2, TEMPERATURE(C)
    DEFINE P(4) AS COLUMN=T1, DUTY(4,WATT)
    DEFINE P(5) AS STREAM=PA3, TEMPERATURE(C)
    PROCEDURE
        R1=P1
        R2=P2
        R3=P3
        R4=P4
        R5=P5
    RETURN
CALCULATOR UID=CA4
    DEFINE P(1) AS STREAM=RESIDUE, TEMPERATURE(C)
    DEFINE P(2) AS COLUMN=T1, DUTY(1,KW)
    DEFINE P(3) AS COLUMN=T1, TRAY=2, TEMPERATURE(C)
    DEFINE P(4) AS COLUMN=T1, TRAY=29, TEMPERATURE(C)
    DEFINE P(5) AS COLUMN=T1, DUTY(2,WATT)
    PROCEDURE
        R1=P1
        R2=P2
        R3=P3
        R4=P4
        R5=P5
    RETURN
CALCULATOR UID=CA3

```

```

DEFINE P(1) AS STREAM=DIESEL, D86(5,C), MINUS,
STREAM=KEROSENE, &
    D86(95,C)
DEFINE P(2) AS STREAM=AGO, D86(5,C), MINUS, STREAM=DIESEL, &
    D86(95,C)
DEFINE P(3) AS STREAM=KEROSENE, TEMPERATURE(C)
DEFINE P(4) AS STREAM=DIESEL, TEMPERATURE(C)
DEFINE P(5) AS STREAM=AGO, TEMPERATURE(C)
PROCEDURE
    R1=P1
    R2=P2
    R3=P3
    R4=P4
    R5=P5
    RETURN
CALCULATOR UID=CA2
    DEFINE P(1) AS STREAM=KSTEAM, RATE(WT,LB/H),TOTAL,WET,
    DIVIDE, &
        STREAM=KEROSENE, RATE(LV,BBL/H),TOTAL,WET
    DEFINE P(2) AS STREAM=DSTEAM, RATE(WT,LB/H),TOTAL,WET,
    DIVIDE, &
        STREAM=DIESEL, RATE(LV,BBL/H),TOTAL,WET
    DEFINE P(3) AS STREAM=ASTEAM, RATE(WT,LB/H),TOTAL,WET,
    DIVIDE, &
        STREAM=AGO, RATE(LV,BBL/H),TOTAL,WET
    DEFINE P(4) AS STREAM=RSTEAM, RATE(WT,LB/H),TOTAL,WET,
    DIVIDE, &
        STREAM=RESIDUE, RATE(LV,BBL/H),TOTAL,WET
    DEFINE P(5) AS STREAM=KEROSENE, D86(5,C), MINUS, &
        STREAM=NAPHTHA, D86(95,C)
PROCEDURE
    R1=P1
    R2=P2
    R3=P3
    R4=P4
    R5=P5
    RETURN
CALCULATOR UID=CA1
    DEFINE P(1) AS STREAM=NAPHTHA, RATE(LV,M3/H),TOTAL,WET
    DEFINE P(2) AS STREAM=KEROSENE, RATE(LV,M3/H),TOTAL,WET
    DEFINE P(3) AS STREAM=DIESEL, RATE(LV,M3/H),TOTAL,WET
    DEFINE P(4) AS STREAM=AGO, RATE(LV,M3/H),TOTAL,WET
    DEFINE P(5) AS STREAM=RESIDUE, RATE(LV,M3/H),TOTAL,WET
PROCEDURE
    R1=P1
    R2=P2
    R3=P3

```

```
R4=P4
R5=P5
RETURN
HX UID=E13
  HOT FEED=S19, M=S20
  OPER HTEMP=232.22
HX UID=E12
  HOT FEED=S17, M=S18
  OPER HTEMP=171.11
HX UID=E11
  HOT FEED=S15, M=S16
  OPER HTEMP=104.44
HX UID=E10
  HOT FEED=S13, M=S14
  OPER HTEMP=260
HX UID=E9
  HOT FEED=S11, M=S12
  OPER HTEMP=21.111
HX UID=E8
  HOT FEED=S9, M=S10
  OPER HTEMP=21.111
HX UID=E6
  HOT FEED=S5, M=S6
  OPER HTEMP=21.111
HX UID=E5
  HOT FEED=S3, M=S4
  OPER HTEMP=21.111
HX UID=E4
  HOT FEED=S1, M=S2
  OPER HTEMP=21.111
END
```

Appendix D The formulas of the annual cost and the net present value (NPV).

The annual costs

The annual costs (\$/year) = Operating costs (\$/year) + Fixed costs (\$/year)

Operating costs

Operating costs (\$/year) = Utilities costs (\$/year)

Utilities costs (\$/year) = Cooling utility costs (\$/year) + Furnace costs (\$/year)

Cost data:

Fuel gas = \$6.83/ (MW h)

Cooling water = \$1.2287/ (MW h)

Assuming: Working days per year = 24*365 h

Fixed costs

Fixed costs (\$/year) = Heat exchanger costs (\$/year)

Heat exchanger costs (\$/year) = $1168.5A^{0.65}$ (A in m^2) / Depreciation life (years)

Cost data:

Depreciation life = 10 years

The Net Present Value (NPV)

NPV =

$$-(C_I + C_W) + \sum_{j=1}^n (R - X)_j (1 - t) / (1 + i)^j + \sum_{j=1}^{n_t} D_j t / (1 + i)^j + (C_S + C_W) / (1 + i)^n$$

C_I = Fixed capital investment = $1168.5 A^{0.65}$ (A in m^2)

R = Furnace and cooling water costs before retrofit

X = Furnace and cooling water costs after retrofit

C_S = Salvage value = assuming = \$0

C_W = Working capital = assuming = \$0

$D = \text{Depreciation/year} = C_I/n_t$

$t = \text{Tax rate} = \text{assuming} = 30 \%$.

$i = \text{after tax rate of return} = \text{Interest} = 5 \%$. $n = \text{useful plant life} = 15 \text{ years}$

$n_t = \text{Depreciation life (tax purpose)} = 10 \text{ years}$

Fuel gas cost = \$6.83/ (MW/h)

Cooling cost = \$1.2287/ (MW/h)

Assuming: Working days per year = $24 \times 365 \text{ h}$

Appendix E Simulation data to keyword for light crude of area optimization .

\$ Generated by PRO/II Keyword Generation System <version 5.61>

\$ Generated on: Mon May 03 01:14:11 2004

TITLE

TOLERANCE STREAM=0.001

DIMENSION SI, TEMP=C, ENERGY=KWH, DUTY=WATT, HTCOEF=BTU/H,

&

STDTEMP=0, STDPRES=101.325

SEQUENCE SIMSCI

CALCULATION RVPBASIS=APIN, TVP=37.778, RECYCLE=ALL

COMPONENT DATA

LIBID

1,ETHANE/2,PROPANE/3,IBUTANE/4,BUTANE/5,IPENTANE/6,PENTANE/ &

7,H2O

THERMODYNAMIC DATA

METHOD SYSTEM=GS, SET=GS01, DEFAULT

STREAM DATA

PROPERTY STREAM=CRUDE, TEMPERATURE=21.111, PRESSURE=446.06,

PHASE=M, &

RATE(LV)=794.999, ASSAY=LV

TBP STREAM=CRUDE, DATA=5,45/10,82/30,186/50,281/70,382/90,552, &

TEMP=C

API STREAM=CRUDE, AVERAGE=36

LIGHTEND STREAM=CRUDE,

COMPOSITION(M)=1,0.13/2,0.78/3,0.49/4,1.36/ &

5,1.05/6,1.3, MATCH

PROPERTY STREAM=WATER, TEMPERATURE=21.111, PRESSURE=446.06,

PHASE=M, &

RATE(M)=4535.93, COMPOSITION(M)=7,1

PROPERTY STREAM=RSTEAM, TEMPERATURE=260, PRESSURE=446.06,

PHASE=M, &

RATE(WT)=6020.06, COMPOSITION(M)=7,1
 PROPERTY STREAM=KSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=6673, COMPOSITION(M)=7,1
 PROPERTY STREAM=DSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=1991, COMPOSITION(M)=7,1
 PROPERTY STREAM=ASTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=3452.15, COMPOSITION(M)=7,1
 PROPERTY STREAM=S1, REFSTREAM=MIXED
 UNIT OPERATIONS
 MIXER UID=M1
 FEED CRUDE,WATER
 PRODUCT M=MIXED
 HX UID=E1
 COLD FEED=MIXED, M=HEATED
 OPER CTEMP=104.44
 FLASH UID=F1
 FEED HEATED
 PRODUCT W=SW, V=DESALTED
 ADIABATIC
 HX UID=E2
 COLD FEED=DESALTED, M=HDESALTED, DP=34.474
 OPER CTEMP=204.44
 HX UID=E3
 COLD FEED=HDESALTED, M=FEEDCRUDE, DP=206.84
 OPER CTEMP=360
 COLUMN UID=T1
 PARAMETER TRAY=34,IO
 FEED
 FEEDCRUDE,29/KTURN,8/DTURN,15/ATURN,24/RSTEAM,34,SEPARATE

PRODUCT OVHD(LV)=NAPHTHA,250, WATER(M)=DECANTED,1, &
 LDRAW(LV)=KDRAWN,9,144, LDRAW(LV)=DDRAWN,16,69.9998,
 &
 LDRAW(LV)=ADRAWN,25,121, BTMS(LV)=RESIDUE,211, &
 SUPERSEDE=ON
 CONDENSER TYPE=TFIX, TEMPERATURE=43.333
 DUTY 1,1/2,2,-21/3,10,-38/4,17,-5
 PA FROM=4, TO=2, PHASE=L, TEMP=104.444
 PA FROM=12, TO=10, PHASE=L, TEMP=171.111
 PA FROM=19, TO=17, PHASE=L, TEMP=232.222
 PRINT PROPTABLE=PART
 ESTIMATE MODEL=REFINING
 PRESSURE 1,206.815/2,210.262/34,279.21
 SPEC STREAM=NAPHTHA, D86(95,C), VALUE=182
 SPEC STREAM=KEROSENE, D86(95,C), VALUE=271
 SPEC STREAM=DIESEL, D86(95,C), VALUE=327
 SPEC TRAY=28, RATE(LV,BBL/H), PHASE=L,WET, DIVIDE, &
 STREAM=FEEDCRUDE, RATE(LV,BBL/H),TOTAL,WET, &
 VALUE=0.03
 VARY DUTY=1
 VARY DRAW=KDRAWN,DDRAWN,ADRAWN
 TFLOW TOT(V)=COND,2, PA(L)=PA1,4,2/PA2,12,10/PA3,19,17
 SIDESTRIPPER UID=SS1
 PARAMETER TRAY=4,IO
 FEED KDRAWN,1/KSTEAM,4
 PRODUCT OVHD(M)=KTURN, BTMS(LV)=KEROSENE,144
 PSPEC PTOP=218.54
 PRINT PROPTABLE=PART
 SIDESTRIPPER UID=SS2
 PARAMETER TRAY=4,IO
 FEED DDRAWN,1/DSTEAM,4
 PRODUCT OVHD(M)=DTURN, BTMS(LV)=DIESEL,69.9998

PSPEC PTOP=239.22
PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS3
PARAMETER TRAY=4,IO
FEED ADRAWN,1/ASTEAM,4
PRODUCT OVHD(M)=ATURN, BTMS(LV)=AGO,121
PSPEC PTOP=253.01
PRINT PROPTABLE=PART
HX UID=E4
HOT FEED=COND, M=S13
COLD FEED=S1, M=S2
CONFIGURE COUNTER, U=40, AREA=100
HX UID=E13
HOT FEED=S13, M=S14
OPER HTEMP=43.333
HX UID=E5
HOT FEED=PA1, M=S15
COLD FEED=S2, M=S3
CONFIGURE COUNTER, U=37.5, AREA=100
HX UID=E14
HOT FEED=S15, M=S16
OPER HTEMP=104.44
HX UID=E6
HOT FEED=KEROSENE, M=S17
COLD FEED=S3, M=S4
CONFIGURE COUNTER, U=35, AREA=100
HX UID=E15
HOT FEED=S17, M=S18
OPER HTEMP=21.11
HX UID=E7
HOT FEED=PA2, M=S19
COLD FEED=S4, M=S5

```

CONFIGURE COUNTER, U=30, AREA=100
HX UID=E16
HOT FEED=S19, M=S20
OPER HTEMP=171.11
CALCULATOR UID=CA1
CONSTANT 1,1168.5/2,0.65/3,10/4,1.2287/5,24/6,365
DEFINE P(1) AS HX=E4, AREA(M2)
DEFINE P(2) AS HX=E5, AREA(M2)
DEFINE P(3) AS HX=E6, AREA(M2)
DEFINE P(4) AS HX=E7, AREA(M2)
DEFINE P(5) AS HX=E13, DUTY(WATT)
DEFINE P(6) AS HX=E14, DUTY(WATT)
DEFINE P(7) AS HX=E15, DUTY(WATT)
DEFINE P(8) AS HX=E16, DUTY(WATT)
PROCEDURE
R1=P1+P2+P3+P4
R2=P5+P6+P7+P8
R3=(C1*(R1**C2))/C3
R4=C4*C5*C6*R2
R5=R3+R4
RETURN
OPTIMIZER UID=OP1
SPEC ID=OPT1SPEC1, STREAM=S5, TEMPERATURE(C), VALUE=104.44
VARY ID=OPT1VARY1, HX=E4, AREA(M2), MINI=0, MAXI=1000
VARY ID=OPT1VARY2, HX=E7, AREA(M2), MINI=0, MAXI=1000
VARY ID=OPT1VARY3, HX=E6, AREA(M2), MINI=0, MAXI=1000
VARY ID=OPT1VARY4, HX=E5, AREA(M2), MINI=0, MAXI=1000
OBJECTIVE CALCULATOR=CA1, R(5), MINIMIZE
FLASH UID=F2
FEED S5
PRODUCT W=S6, V=S7
ADIABATIC

```

HX UID=E8

HOT FEED=DIESEL, M=S21

COLD FEED=S7, M=S8

CONFIGURE COUNTER, U=27.5, AREA=100

HX UID=E17

HOT FEED=S21, M=S22

OPER HTEMP=21.11

HX UID=E9

HOT FEED=PA3, M=S23

COLD FEED=S8, M=S9

CONFIGURE COUNTER, U=25, AREA=100

HX UID=E18

HOT FEED=S23, M=S24

OPER HTEMP=232.22

HX UID=E10

HOT FEED=AGO, M=S25

COLD FEED=S9, M=S10

CONFIGURE COUNTER, U=20, AREA=100

HX UID=E19

HOT FEED=S25, M=S26

OPER HTEMP=21.11

HX UID=E11

HOT FEED=RESIDUE, M=S27

COLD FEED=S10, M=S11

CONFIGURE COUNTER, U=23, AREA=100

HX UID=E20

HOT FEED=S27, M=S28

OPER HTEMP=260

HX UID=E12

COLD FEED=S11, M=S12

OPER DUTY=1

CALCULATOR UID=CA2

```

CONSTANT 1,1168.5/2,0.65/3,10/4,6.83/5,24/6,365/7,1.2287
DEFINE P(1) AS HX=E8, AREA(M2)
DEFINE P(2) AS HX=E9, AREA(M2)
DEFINE P(3) AS HX=E10, AREA(M2)
DEFINE P(4) AS HX=E11, AREA(M2)
DEFINE P(5) AS HX=E12, DUTY(WATT)
DEFINE P(6) AS HX=E17, DUTY(WATT)
DEFINE P(7) AS HX=E18, DUTY(WATT)
DEFINE P(8) AS HX=E19, DUTY(WATT)
DEFINE P(9) AS HX=E20, DUTY(WATT)
PROCEDURE
  R1=P1+P2+P3+P4
  R2=P6+P7+P8+P9
  R3=C1*(R1**C2)/C3
  R4=C4*P5*C5*C6
  R5=C7*C5*C6*R2
  R6=R3+R4+R5
RETURN
OPTIMIZER UID=OP2
  SPEC ID=OPT2SPEC1, STREAM=S12, TEMPERATURE(C), VALUE=360
  VARY ID=OPT2VARY1, HX=E8, AREA(M2), MINI=0, MAXI=10000
  VARY ID=OPT2VARY4, HX=E9, AREA(M2), MINI=0, MAXI=500
  VARY ID=OPT2VARY2, HX=E12, DUTY(WATT), MINI=0, MAXI=2000
  VARY ID=OPT2VARY3, HX=E11, AREA(M2), MINI=0, MAXI=1000
  VARY ID=OPT2VARY5, HX=E10, AREA(M2), MINI=0, MAXI=10000
  CONSTRAINT ID=OPT2CONS1, STREAM=S23, TEMPERATURE(C), &
    MINI=232.22
  CONSTRAINT ID=OPT2CONS2, STREAM=S27, TEMPERATURE(C),
MINI=260
  OBJECTIVE CALCULATOR=CA2, R(6), MINIMIZE
END

```

Appendix F Simulation data to keyword for intermediate crude of area optimization .

\$ Generated by PRO/II Keyword Generation System <version 5.61>

\$ Generated on: Mon May 03 01:20:43 2004

TITLE

TOLERANCE STREAM=0.001

DIMENSION SI, TEMP=C, ENERGY=KWH, DUTY=WATT, HTCOEF=BTU/H,

&

STDTEMP=0, STDPRES=101.325

SEQUENCE SIMSCI

CALCULATION RVPBASIS=APIN, TVP=37.778, RECYCLE=ALL

COMPONENT DATA

LIBID

1,ETHANE/2,PROPANE/3,IBUTANE/4,BUTANE/5,IPENTANE/6,PENTANE/ &
7,H2O

THERMODYNAMIC DATA

METHOD SYSTEM=GS, SET=GS01, DEFAULT

STREAM DATA

PROPERTY STREAM=CRUDE, TEMPERATURE=21.111, PRESSURE=446.06,
PHASE=M, &

RATE(LV)=794.999, ASSAY=LV

TBP STREAM=CRUDE, DATA=5,94/10,131/30,265/50,380/70,506/90,670, &
TEMP=C

API STREAM=CRUDE, AVERAGE=27.7

LIGHTEND STREAM=CRUDE, COMPOSITION(M)=1,0.1/2,0.3/3,0.2/4,0.7, &
MATCH

PROPERTY STREAM=WATER, TEMPERATURE=21.111, PRESSURE=446.06,
PHASE=M, &

RATE(M)=4535.93, COMPOSITION(M)=7,1

PROPERTY STREAM=RSTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=12173, COMPOSITION(M)=7,1
 PROPERTY STREAM=KSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=2707.17, COMPOSITION(M)=7,1
 PROPERTY STREAM=DSTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=1731, COMPOSITION(M)=7,1
 PROPERTY STREAM=ASTEAM, TEMPERATURE=260, PRESSURE=446.06,
 PHASE=M, &
 RATE(WT)=1672.89, COMPOSITION(M)=7,1
 PROPERTY STREAM=S1, REFSTREAM=MIXED
 UNIT OPERATIONS
 MIXER UID=M1
 FEED CRUDE,WATER
 PRODUCT M=MIXED
 HX UID=E1
 COLD FEED=MIXED, M=HEATED
 OPER CTEMP=104.44
 FLASH UID=F1
 FEED HEATED
 PRODUCT W=SW, V=DESALTED
 ADIABATIC
 HX UID=E2
 COLD FEED=DESALTED, M=HDESALTED, DP=34.474
 OPER CTEMP=204.44
 HX UID=E3
 COLD FEED=HDESALTED, M=FEEDCRUDE, DP=206.84
 OPER CTEMP=360
 COLUMN UID=T1
 PARAMETER TRAY=34,IO
 FEED
 FEEDCRUDE,29/KTURN,8/DTURN,15/ATURN,24/RSTEAM,34,SEPARATE

PRODUCT OVHD(LV)=NAPHTHA,154.5, WATER(M)=DECANTED,1, &
 LDRAW(LV)=KDRAWN,9,94.8892, LDRAW(LV)=DDRAWN,16, &
 60.673, LDRAW(LV)=ADRAWN,25,58.6361, BTMS(LV)=RESIDUE, &
 426.679, SUPERSEDE=ON
 CONDENSER TYPE=TFIX, TEMPERATURE=43.333
 DUTY 1,1/2,2,-25/3,10,-13/4,17,-2
 PA FROM=4, TO=2, PHASE=L, TEMP=104.444
 PA FROM=12, TO=10, PHASE=L, TEMP=171.111
 PA FROM=19, TO=17, PHASE=L, TEMP=232.222
 PRINT PROPTABLE=PART
 ESTIMATE MODEL=REFINING
 PRESSURE 1,206.815/2,210.262/34,279.21
 SPEC STREAM=NAPHTHA, D86(95,C), VALUE=182
 SPEC STREAM=KEROSENE, D86(95,C), VALUE=271
 SPEC STREAM=DIESEL, D86(95,C), VALUE=327
 SPEC TRAY=28, RATE(LV,BBL/H), PHASE=L,WET, DIVIDE, &
 STREAM=FEEDCRUDE, RATE(LV,BBL/H),TOTAL,WET, &
 VALUE=0.03
 VARY DUTY=1
 VARY DRAW=KDRAWN,DDRAWN,ADRAWN
 TFLOW TOT(V)=COND,2, PA(L)=PA3,19,17/PA2,12,10/PA1,4,2
 SIDESTRIPPER UID=SS1
 PARAMETER TRAY=4,IO
 FEED KDRAWN,1/KSTEAM,4
 PRODUCT OVHD(M)=KTURN, BTMS(LV)=KEROSENE,144
 PSPEC PTOP=218.54
 PRINT PROPTABLE=PART
 SIDESTRIPPER UID=SS2
 PARAMETER TRAY=4,IO
 FEED DDRAWN,1/DSTEAM,4
 PRODUCT OVHD(M)=DTURN, BTMS(LV)=DIESEL,69.9998
 PSPEC PTOP=239.22

PRINT PROPTABLE=PART
SIDESTRIPPER UID=SS3
PARAMETER TRAY=4,IO
FEED ADRAWN,1/ASTEAM,4
PRODUCT OVHD(M)=ATURN, BTMS(LV)=AGO,121
PSPEC PTOP=253.01
PRINT PROPTABLE=PART
HX UID=E4
HOT FEED=COND, M=S13
COLD FEED=S1, M=S2
CONFIGURE COUNTER, U=40, AREA=1
HX UID=E14
HOT FEED=S13, M=S14
OPER HTEMP=43.333
HX UID=E6
HOT FEED=PA1, M=S15
COLD FEED=S2, M=S3
CONFIGURE COUNTER, U=37.5, AREA=1
HX UID=E15
HOT FEED=S15, M=S16
OPER HTEMP=104.44
HX UID=E7
HOT FEED=KEROSENE, M=S19
COLD FEED=S3, M=S4
CONFIGURE COUNTER, U=35, AREA=1
HX UID=E16
HOT FEED=S19, M=S20
OPER HTEMP=21.11
HX UID=E8
HOT FEED=PA2, M=S21
COLD FEED=S4, M=S5
CONFIGURE COUNTER, U=30, AREA=1

```

HX UID=E17
  HOT FEED=S21, M=S22
  OPER HTEMP=171.11
CALCULATOR UID=CA1
  CONSTANT 1,1168.5/2,0.65/3,10/4,1.2287/5,24/6,365
  DEFINE P(1) AS HX=E4, AREA(M2)
  DEFINE P(2) AS HX=E6, AREA(M2)
  DEFINE P(3) AS HX=E7, AREA(M2)
  DEFINE P(4) AS HX=E8, AREA(M2)
  DEFINE P(5) AS HX=E14, DUTY(WATT)
  DEFINE P(6) AS HX=E15, DUTY(WATT)
  DEFINE P(7) AS HX=E16, DUTY(WATT)
  DEFINE P(8) AS HX=E17, DUTY(WATT)
  PROCEDURE
    R1=P1+P2+P3+P4
    R2=P5+P6+P7+P8
    R3=(C1*(R1**C2))/C3
    R4=C4*C5*C6*R2
    R5=R3+R4
  RETURN
OPTIMIZER UID=OP1
  SPEC ID=OPT1SPEC1, STREAM=S5, TEMPERATURE(C), VALUE=104.44
  VARY ID=OPT1VARY1, HX=E4, AREA(M2), MINI=0, MAXI=1000
  VARY ID=OPT1VARY2, HX=E8, AREA(M2), MINI=0, MAXI=1000
  VARY ID=OPT1VARY3, HX=E7, AREA(M2), MINI=0, MAXI=1000
  VARY ID=OPT1VARY4, HX=E6, AREA(M2), MINI=0, MAXI=1000
  OBJECTIVE CALCULATOR=CA1, R(5), MINIMIZE
FLASH UID=F2
  FEED S5
  PRODUCT W=S6, V=S7
  ADIABATIC
HX UID=E9

```

HOT FEED=DIESEL, M=S23
COLD FEED=S7, M=S8
CONFIGURE COUNTER, U=27.5, AREA=1
HX UID=E18
HOT FEED=S23, M=S24
OPER HTEMP=21.11
HX UID=E10
HOT FEED=PA3, M=S25
COLD FEED=S8, M=S9
CONFIGURE COUNTER, U=25, AREA=1
HX UID=E19
HOT FEED=S25, M=S26
OPER HTEMP=232.22
HX UID=E11
HOT FEED=AGO, M=S27
COLD FEED=S9, M=S10
CONFIGURE COUNTER, U=20, AREA=1
HX UID=E20
HOT FEED=S27, M=S28
OPER HTEMP=21.11
HX UID=E12
HOT FEED=RESIDUE, M=S29
COLD FEED=S10, M=S11
CONFIGURE COUNTER, U=23, AREA=1
HX UID=E21
HOT FEED=S29, M=S30
OPER HTEMP=260
HX UID=E13
COLD FEED=S11, M=S12
OPER DUTY=1
CALCULATOR UID=CA2
CONSTANT 1,1168.5/2,0.65/3,10/4,6.83/5,24/6,365/7,1.2287

```

DEFINE P(1) AS HX=E9, AREA(M2)
DEFINE P(2) AS HX=E10, AREA(M2)
DEFINE P(3) AS HX=E11, AREA(M2)
DEFINE P(4) AS HX=E12, AREA(M2)
DEFINE P(5) AS HX=E13, DUTY(WATT)
DEFINE P(6) AS HX=E18, DUTY(WATT)
DEFINE P(7) AS HX=E19, DUTY(WATT)
DEFINE P(8) AS HX=E20, DUTY(WATT)
DEFINE P(9) AS HX=E21, DUTY(WATT)
PROCEDURE
  R1=P1+P2+P3+P4
  R2=P6+P7+P8+P9
  R3=C1*(R1**C2)/C3
  R4=C4*P5*C5*C6
  R5=C7*C5*C6*R2
  R6=R3+R4+R5
  RETURN
OPTIMIZER UID=OP2
  SPEC ID=OPT2SPEC1, STREAM=S12, TEMPERATURE(C), VALUE=360
  VARY ID=OPT2VARY1, HX=E9, AREA(M2), MINI=0, MAXI=10000
  VARY ID=OPT2VARY2, HX=E12, AREA(M2), MINI=0, MAXI=2000
  VARY ID=OPT2VARY3, HX=E11, AREA(M2), MINI=0, MAXI=10000
  VARY ID=OPT2VARY4, HX=E10, AREA(M2), MINI=0, MAXI=1000
  VARY ID=OPT2VARY5, HX=E13, DUTY(WATT), MINI=0, MAXI=2000
  CONSTRAINT ID=OPT2CONS1, STREAM=S25, TEMPERATURE(C), &
    MINI=232.22
  CONSTRAINT ID=OPT2CONS2, STREAM=S29, TEMPERATURE(C),
MINI=260
  OBJECTIVE CALCULATOR=CA2, R(6), MINIMIZE
END

```

Appendix G Simulation data to keyword for heavy crude of area optimization .

\$ Generated by PRO/II Keyword Generation System <version 5.61>

\$ Generated on: Mon May 03 01:22:51 2004

TITLE

TOLERANCE STREAM=0.001

DIMENSION SI, TEMP=C, ENERGY=KWH, DUTY=WATT, HTCOEF=BTU/H,
&

STDTEMP=0, STDPRES=101.325

SEQUENCE SIMSCI

CALCULATION RVPBASIS=APIN, TVP=37.778, RECYCLE=ALL

COMPONENT DATA

LIBID

1,ETHANE/2,PROPANE/3,IBUTANE/4,BUTANE/5,IPENTANE/6,PENTANE/ &
7,H2O

THERMODYNAMIC DATA

METHOD SYSTEM=GS, SET=GS01, DEFAULT

STREAM DATA

PROPERTY STREAM=CRUDE, TEMPERATURE=21.111, PRESSURE=446.06,
PHASE=M, &

RATE(LV)=794.999, ASSAY=LV

TBP STREAM=CRUDE, DATA=5,133/10,237/30,344/50,482/70,640, TEMP=C

API STREAM=CRUDE, AVERAGE=20

LIGHTEND STREAM=CRUDE,

COMPOSITION(M)=2,0.04/3,0.04/4,0.11/5,0.14/ &

6,0.16, MATCH

PROPERTY STREAM=WATER, TEMPERATURE=21.111, PRESSURE=446.06,
PHASE=M, &

RATE(M)=4535.93, COMPOSITION(M)=7,1

PROPERTY STREAM=RSTEAM, TEMPERATURE=260, PRESSURE=446.06,

PHASE=M, &

RATE(WT)=17284.1, COMPOSITION(M)=7,1

PROPERTY STREAM=KSTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=1392.26, COMPOSITION(M)=7,1

PROPERTY STREAM=DSTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=1705.23, COMPOSITION(M)=7,1

PROPERTY STREAM=ASTEAM, TEMPERATURE=260, PRESSURE=446.06,
PHASE=M, &

RATE(WT)=2373.78, COMPOSITION(M)=7,1

PROPERTY STREAM=S1, REFSTREAM=MIXED

UNIT OPERATIONS

MIXER UID=M1

FEED CRUDE,WATER

PRODUCT M=MIXED

HX UID=E1

COLD FEED=MIXED, M=HEATED

OPER CTEMP=104.44

FLASH UID=F1

FEED HEATED

PRODUCT W=SW, V=DESALTED

ADIABATIC

HX UID=E2

COLD FEED=DESALTED, M=HDESALTED, DP=34.474

OPER CTEMP=204.44

HX UID=E3

COLD FEED=HDESALTED, M=FEEDCRUDE, DP=206.84

OPER CTEMP=360

COLUMN UID=T1

PARAMETER TRAY=34,IO

FEED

FEEDCRUDE,29/KTURN,8/DTURN,15/ATURN,24/RSTEAM,34,SEPARATE

PRODUCT OVHD(LV)=NAPHTHA,56.4674, WATER(M)=DECANTED,1, &

LDRAW(LV)=KDRAWN,9,48.7994, LDRAW(LV)=DDRAWN,16, &
 59.7218, LDRAW(LV)=ADRAWN,25,24.5364, &
 BTMS(LV)=RESIDUE,605.819, SUPERSEDE=ON
 CONDENSER TYPE=TFIX, TEMPERATURE=21.111
 DUTY 1,1/2,2,-18/3,10,-9/4,17,-1
 PA FROM=4, TO=2, PHASE=L, TEMP=104.444
 PA FROM=12, TO=10, PHASE=L, TEMP=171.111
 PA FROM=19, TO=17, PHASE=L, TEMP=232.222
 PRINT PROPTABLE=PART
 ESTIMATE MODEL=REFINING
 PRESSURE 1,206.815/2,210.262/34,279.21
 SPEC STREAM=NAPHTHA, D86(95,C), VALUE=182
 SPEC STREAM=KEROSENE, D86(95,C), VALUE=271
 SPEC STREAM=DIESEL, D86(95,C), VALUE=327
 SPEC TRAY=28, RATE(LV,BBL/H), PHASE=L,WET, DIVIDE, &
 STREAM=FEEDCRUDE, RATE(LV,BBL/H),TOTAL,WET, &
 VALUE=0.03
 VARY DUTY=1
 VARY DRAW=KDRAWN,DDRAWN,ADRAWN
 TFLOW TOT(V)=COND,2, PA(L)=PA3,19,17/PA2,12,10/PA1,4,2
 SIDESTRIPPER UID=SS1
 PARAMETER TRAY=4,IO
 FEED KDRAWN,1/KSTEAM,4
 PRODUCT OVHD(M)=KTURN, BTMS(LV)=KEROSENE,144
 PSPEC PTOP=218.54
 PRINT PROPTABLE=PART
 SIDESTRIPPER UID=SS2
 PARAMETER TRAY=4,IO
 FEED DDRAWN,1/DSTEAM,4
 PRODUCT OVHD(M)=DTURN, BTMS(LV)=DIESEL,69.9998
 PSPEC PTOP=239.22
 PRINT PROPTABLE=PART

SIDESTRIPPER UID=SS3

PARAMETER TRAY=4,IO

FEED ADRAWN,1/ASTEAM,4

PRODUCT OVHD(M)=ATURN, BTMS(LV)=AGO,121

PSPEC PTOP=253.01

PRINT PROPTABLE=PART

HX UID=E4

HOT FEED=COND, M=S13

COLD FEED=S1, M=S2

CONFIGURE COUNTER, U=40, AREA=1

HX UID=E13

HOT FEED=S13, M=S14

OPER HTEMP=21.11

HX UID=E5

HOT FEED=PA1, M=S15

COLD FEED=S2, M=S3

CONFIGURE COUNTER, U=37.5, AREA=1

HX UID=E14

HOT FEED=S15, M=S16

OPER HTEMP=104.44

HX UID=E6

HOT FEED=KEROSENE, M=S17

COLD FEED=S3, M=S4

CONFIGURE COUNTER, U=35, AREA=1

HX UID=E15

HOT FEED=S17, M=S18

OPER HTEMP=21.11

HX UID=E7

HOT FEED=PA2, M=S19

COLD FEED=S4, M=S5

CONFIGURE COUNTER, U=30, AREA=1

HX UID=E16

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HOT FEED=S19, M=S20
OPER HTEMP=171.11
CALCULATOR UID=CA1
CONSTANT 1,1168.5/2,0.65/3,10/4,1.2287/5,24/6,365
DEFINE P(1) AS HX=E4, AREA(M2)
DEFINE P(2) AS HX=E5, AREA(M2)
DEFINE P(3) AS HX=E6, AREA(M2)
DEFINE P(4) AS HX=E7, AREA(M2)
DEFINE P(5) AS HX=E13, DUTY(WATT)
DEFINE P(6) AS HX=E14, DUTY(WATT)
DEFINE P(7) AS HX=E15, DUTY(WATT)
DEFINE P(8) AS HX=E16, DUTY(WATT)
PROCEDURE
  R1=P1+P2+P3+P4
  R2=P5+P6+P7+P8
  R3=(C1*(R1**C2))/C3
  R4=C4*C5*C6*R2
  R5=R3+R4
RETURN
OPTIMIZER UID=OP1
SPEC ID=OPT1SPEC1, STREAM=S5, TEMPERATURE(C), VALUE=104.44
VARY ID=OPT1VARY1, HX=E4, AREA(M2), MINI=0, MAXI=1000
VARY ID=OPT1VARY2, HX=E7, AREA(M2), MINI=0, MAXI=1000
VARY ID=OPT1VARY3, HX=E6, AREA(M2), MINI=0, MAXI=1000
VARY ID=OPT1VARY4, HX=E5, AREA(M2), MINI=0, MAXI=1000
OBJECTIVE CALCULATOR=CA1, R(5), MINIMIZE
FLASH UID=F2
FEED S5
PRODUCT W=S6, V=S7
ADIABATIC
HX UID=E8
HOT FEED=DIESEL, M=S21

```

COLD FEED=S7, M=S8
CONFIGURE COUNTER, U=27.5, AREA=1
HX UID=E17

HOT FEED=S21, M=S22
OPER HTEMP=21.11
HX UID=E9

HOT FEED=PA3, M=S23
COLD FEED=S8, M=S9
CONFIGURE COUNTER, U=25, AREA=1
HX UID=E18

HOT FEED=S23, M=S24
OPER HTEMP=232.22
HX UID=E10

HOT FEED=AGO, M=S25
COLD FEED=S9, M=S10
CONFIGURE COUNTER, U=20, AREA=1
HX UID=E19

HOT FEED=S25, M=S26
OPER HTEMP=21.11
HX UID=E11

HOT FEED=RESIDUE, M=S27
COLD FEED=S10, M=S11
CONFIGURE COUNTER, U=23, AREA=1
HX UID=E20

HOT FEED=S27, M=S28
OPER HTEMP=260
HX UID=E12

COLD FEED=S11, M=S12
OPER DUTY=1
CALCULATOR UID=CA2
CONSTANT 1,1168.5/2,0.65/3,10/4,6.83/5,24/6,365/7,1.2287

```

DEFINE P(1) AS HX=E8, AREA(M2)
DEFINE P(2) AS HX=E9, AREA(M2)
DEFINE P(3) AS HX=E10, AREA(M2)
DEFINE P(4) AS HX=E11, AREA(M2)
DEFINE P(5) AS HX=E12, DUTY(WATT)
DEFINE P(6) AS HX=E17, DUTY(WATT)
DEFINE P(7) AS HX=E18, DUTY(WATT)
DEFINE P(8) AS HX=E19, DUTY(WATT)
DEFINE P(9) AS HX=E20, DUTY(WATT)
PROCEDURE
  R1=P1+P2+P3+P4
  R2=P6+P7+P8+P9
  R3=C1*(R1**C2)/C3
  R4=C4*P5*C5*C6
  R5=C7*C5*C6*R2
  R6=R3+R4+R5
RETURN
OPTIMIZER UID=OP2
  SPEC ID=OPT2SPEC1, STREAM=S12, TEMPERATURE(C), VALUE=360
  VARY ID=OPT2VARY1, HX=E8, AREA(M2), MINI=0, MAXI=2000
  VARY ID=OPT2VARY3, HX=E12, DUTY(WATT), MINI=0, MAXI=2000
  VARY ID=OPT2VARY4, HX=E11, AREA(M2), MINI=0, MAXI=2500
  VARY ID=OPT2VARY5, HX=E10, AREA(M2), MINI=0, MAXI=10000
  VARY ID=OPT2VARY6, HX=E9, AREA(M2), MINI=0, MAXI=1000
  CONSTRAINT ID=OPT2CONS1, STREAM=S23, TEMPERATURE(C), &
    MINI=232.22
  CONSTRAINT ID=OPT2CONS2, STREAM=S27, TEMPERATURE(C),
MINI=260
  OBJECTIVE CALCULATOR=CA2, R(6), MINIMIZE
END

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