FileEditor:LMP103S0907.out

```
****************************************************************************

        NASA-GLENN CHEMICAL EQUILIBRIUM PROGRAM CEA2, MAY 21, 2004
                  BY  BONNIE MCBRIDE AND SANFORD GORDON
        REFS: NASA RP-1311, PART I, 1994 AND NASA RP-1311, PART II, 1996

****************************************************************************
```

```
problem   case=LMP130S o/f=2,4,6,8,10,
    rocket  frozen  nfz=1
  p,bar=20,25,30,
react
  oxid=H2O(L) wt=100
  oxid=CH3OH(L) wt=100
  oxid=NH3(L) wt=100
  fuel=RP-1 wt=100
end
```

OPTIONS: TP=F HP=F SP=F TV=F UV=F SV=F DETN=F SHOCK=F REFL=F INCD=F
RKT=T FROZ=T EQL=F IONS=F SIUNIT=T DEBUGF=F SHKDBG=F DETDBG=F TRNSPT=F

TRACE= 0.00E+00 S/R= 0.000000E+00 H/R= 0.000000E+00 U/R= 0.000000E+00

Pc,BAR =   20.000000   25.000000   30.000000

Pc/P =

SUBSONIC AREA RATIOS =

SUPERSONIC AREA RATIOS =

NFZ= 1 Mdot/Ac= 0.000000E+00 Ac/At= 0.000000E+00

```
    REACTANT              WT.FRAC   (ENERGY/R),K   TEMP,K  DENSITY
         EXPLODED FORMULA
O: H2O(L)              0.333333   0.000000E+00     0.00  0.0000
        H  2.00000  O  1.00000
O: CH3OH(L)            0.333333   0.000000E+00     0.00  0.0000
        C  1.00000  H  4.00000  O  1.00000
O: NH3(L)              0.333333  -0.860604E+04   239.72  0.0000
        N  1.00000  H  3.00000
F: RP-1                1.000000  -0.297284E+04   298.15  0.0000
        C  1.00000  H  1.95000
```

 SPECIES BEING CONSIDERED IN THIS SYSTEM
(CONDENSED PHASE MAY HAVE NAME LISTED SEVERAL TIMES)
 LAST thermo.inp UPDATE: 9/09/04

```
 g 7/97  *C            tpis79 *CH            g 4/02  CH2
 g 4/02  CH3           g11/00  CH2OH         g 7/00  CH3O
 g 8/99  CH4           g 7/00  CH3OH         srd 01  CH3OOH
 g 8/99  *CN           g12/99  CNN           tpis79 *CO
 g 9/99  *CO2          tpis91  COOH          tpis91 *C2
 g 6/01  C2H           g 1/91  C2H2,acetylene g 5/01  C2H2,vinylidene
```

```
 g 4/02  CH2CO,ketene      g 3/02  O(CH)2O          srd 01  HO(CO)2OH
 g 7/01  C2H3,vinyl        g 9/00  CH3CN            g 6/96  CH3CO,acetyl
 g 1/00  C2H4              g 8/88  C2H4O,ethylen-o  g 8/88  CH3CHO,ethanal
 g 6/00  CH3COOH           srd 01  OHCH2COOH        g 7/00  C2H5
 g 7/00  C2H6              g 8/88  CH3N2CH3         g 8/88  C2H5OH
 g 7/00  CH3OCH3           srd 01  CH3O2CH3         g 7/00  CCN
 tpis91  CNC               srd 01  OCCN             tpis79  C2N2
 g 8/00  C2O               tpis79  *C3              n 4/98  C3H3,1-propynl
 n 4/98  C3H3,2-propynl    g 2/00  C3H4,allene      g 1/00  C3H4,propyne
 g 5/90  C3H4,cyclo-       g 3/01  C3H5,allyl       g 2/00  C3H6,propylene
 g 1/00  C3H6,cyclo-       g 6/01  C3H6O,propylox   g 6/97  C3H6O,acetone
 g 1/02  C3H6O,propanal    g 7/01  C3H7,n-propyl    g 9/85  C3H7,i-propyl
 g 2/00  C3H8              g 2/00  C3H8O,1propanol  g 2/00  C3H8O,2propanol
 srd 01  CNCOCN            g 7/88  C3O2             g tpis  *C4
 g 7/01  C4H2,butadiyne    g 8/00  C4H4,1,3-cyclo-  n10/92  C4H6,butadiene
 n10/93  C4H6,1butyne      n10/93  C4H6,2butyne     g 8/00  C4H6,cyclo-
 n 4/88  C4H8,1-butene     n 4/88  C4H8,cis2-buten  n 4/88  C4H8,tr2-butene
 n 4/88  C4H8,isobutene    g 8/00  C4H8,cyclo-      g10/00  (CH3COOH)2
 n10/84  C4H9,n-butyl      n10/84  C4H9,i-butyl     g 1/93  C4H9,s-butyl
 g 1/93  C4H9,t-butyl      g12/00  C4H10,n-butane   g 8/00  C4H10,isobutane
 g 6/01  C4N2              g 8/00  *C5              g 5/90  C5H6,1,3cyclo-
 g 1/93  C5H8,cyclo-       n 4/87  C5H10,1-pentene  g 2/01  C5H10,cyclo-
 n10/84  C5H11,pentyl      g 1/93  C5H11,t-pentyl   n10/85  C5H12,n-pentane
 n10/85  C5H12,i-pentane   n10/85  CH3C(CH3)2CH3    g 2/93  C6H2
 g11/00  C6H5,phenyl       g 8/00  C6H5O,phenoxy    g 8/00  C6H6
 g 8/00  C6H5OH,phenol     g 1/93  C6H10,cyclo-     n 4/87  C6H12,1-hexene
 g 6/90  C6H12,cyclo-      n10/83  C6H13,n-hexyl    g 6/01  C6H14,n-hexane
 g 7/01  C7H7,benzyl       g 1/93  C7H8             g12/00  C7H8O,cresol-mx
 n 4/87  C7H14,1-heptene   n10/83  C7H15,n-heptyl   n10/85  C7H16,n-heptane
 n10/85  C7H16,2-methylh   n 4/89  C8H8,styrene     n10/86  C8H10,ethylbenz
 n 4/87  C8H16,1-octene    n10/83  C8H17,n-octyl    n 4/85  C8H18,n-octane
 n 4/85  C8H18,isooctane   n10/83  C9H19,n-nonyl    g 3/01  C10H8,naphthale
 n10/83  C10H21,n-decyl    g 8/00  C12H9,o-bipheny  g 8/00  C12H10,biphenyl
 g 6/97  *H                g 6/01  HCN              g 1/01  HCO
 tpis89  HCCN              g 6/01  HCCO             g 6/01  HNC
 g 7/00  HNCO              g10/01  HNO              tpis89  HNO2
 g 5/99  HNO3              g 4/02  HO2              tpis78  *H2
 g 5/01  HCHO,formaldehy   g 6/01  HCOOH            g 8/89  H2O
 g 6/99  H2O2              g 6/01  (HCOOH)2         g 5/97  *N
 g 6/01  NCO               g 4/99  *NH              g 3/01  NH2
 tpis89  NH3               tpis89  NH2OH            tpis89  *NO
 g 4/99  NO2               j12/64  NO3              tpis78  *N2
 g 6/01  NCN               g 5/99  N2H2             tpis89  NH2NO2
 g 4/99  N2H4              g 4/99  N2O              g 4/99  N2O3
 tpis89  N2O4              g 4/99  N2O5             tpis89  N3
 g 4/99  N3H               g 5/97  *O               g 4/02  *OH
 tpis89  *O2               g 8/01  O3               n 4/83  C(gr)
 n 4/83  C(gr)             n 4/83  C(gr)            g11/99  H2O(cr)
 g 8/01  H2O(L)            g 8/01  H2O(L)
```

```
 O/F =   2.000000
```

	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL)(K)/KG	-0.21270751E+03	-0.16844346E+03	-0.18319814E+03
KG-FORM.WT./KG	bi(2)	bi(1)	b0i

FileEditor:LMP103S0907.out

```
 *H                    0.13952307E+00      0.13733597E+00      0.13806500E+00
 *O                    0.00000000E+00      0.28905870E-01      0.19270580E-01
 *C                    0.71550294E-01      0.10403058E-01      0.30785470E-01
 *N                    0.00000000E+00      0.19572704E-01      0.13048470E-01


 POINT ITN     T          H          O          C          N

   1   21   1149.066     -7.818    -35.203     -1.016    -12.342


 ADD  C(gr)
   1    3   1146.164     -7.738    -34.798     -1.727    -12.350
```

           THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   290.1 PSIA
CASE = LMP130S

```
              REACTANT                   WT FRACTION      ENERGY       TEMP
                                         (SEE NOTE)      KJ/KG-MOL      K
OXIDANT     H2O(L)                       0.3333333        0.000        0.000
OXIDANT     CH3OH(L)                     0.3333333        0.000        0.000
OXIDANT     NH3(L)                       0.3333333      -71555.000    239.720
FUEL        RP-1                         1.0000000      -24717.700    298.150
```

O/F=   2.00000 %FUEL= 33.333333 R,EQ.RATIO= 6.777349 PHI,EQ.RATIO=-1.757209

```
                 CHAMBER    THROAT
Pinf/P            1.0000    1.8073
P, BAR           20.000    11.066
T, K           1146.16    1017.40
RHO, KG/CU M    2.7315 0  1.7027 0
H, KJ/KG       -1523.20   -1931.84
U, KJ/KG       -2255.41   -2581.79
G, KJ/KG      -18613.5   -17102.2
S, KJ/(KG)(K)   14.9108   14.9108


M, (1/n)         13.015    13.015
MW, MOL WT       11.826    11.826
Cp, KJ/(KG)(K)    3.2260    3.1202
GAMMAs            1.2469    1.2575
SON VEL,M/SEC     955.5     904.0
MACH NUMBER       0.000     1.000
```

PERFORMANCE PARAMETERS

```
Ae/At                      1.0000
CSTAR, M/SEC               1299.3
CF                         0.6958
Ivac, M/SEC               1623.0
Isp, M/SEC                 904.0
```

MOLE FRACTIONS

```
CH4              0.12849   *CO            0.12885   *CO2           0.01530
C2H4             0.00001   C2H6           0.00002   HCN            0.00001
*H2              0.49010   H2O            0.06844   NH3            0.00052
*N2              0.07689   C(gr)          0.09138
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

    PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
    WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

```
POINT ITN      T           H           O           C           N

  1    3    1162.002     -7.654     -34.428      -1.748     -12.254
```

        THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   362.6 PSIA
CASE = LMP130S

```
                REACTANT              WT FRACTION      ENERGY       TEMP
                                      (SEE NOTE)     KJ/KG-MOL       K
OXIDANT    H2O(L)                     0.3333333         0.000      0.000
OXIDANT    CH3OH(L)                   0.3333333         0.000      0.000
OXIDANT    NH3(L)                     0.3333333    -71555.000    239.720
FUEL       RP-1                       1.0000000    -24717.700    298.150
```

O/F=   2.00000 %FUEL= 33.333333 R,EQ.RATIO= 6.777349 PHI,EQ.RATIO=-1.757209

```
                CHAMBER   THROAT
Pinf/P           1.0000   1.8053
P, BAR           25.000   13.848
T, K            1162.00  1032.96
RHO, KG/CU M    3.3927 0 2.1141 0
H, KJ/KG       -1523.20 -1933.98
U, KJ/KG       -2260.09 -2589.03
G, KJ/KG       -18684.6 -17189.6
S, KJ/(KG)(K)   14.7688  14.7688

M, (1/n)         13.111   13.111
MW, MOL WT       11.976   11.976
Cp, KJ/(KG)(K)   3.2362   3.1292
GAMMAs           1.2437   1.2542
```

FileEditor:LMP103S0907.out

```
SON VEL,M/SEC       957.3     906.4
MACH NUMBER         0.000     1.000


PERFORMANCE PARAMETERS

Ae/At                       1.0000
CSTAR, M/SEC                1304.7
CF                          0.6947
Ivac, M/SEC                1629.1
Isp, M/SEC                  906.4

MOLE FRACTIONS

CH4         0.13644  *CO          0.13034  *CO2         0.01529
C2H4        0.00001  C2H6         0.00002  HCN          0.00001
*H2         0.48303  H2O          0.06987  NH3          0.00059
*N2         0.07784  C(gr)        0.08656
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

```
POINT ITN      T           H          O          C          N

  1    3   1175.184     -7.586     -34.126     -1.766     -12.175
```


          THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   435.1 PSIA
CASE = LMP130S

```
             REACTANT                WT FRACTION     ENERGY      TEMP
                                     (SEE NOTE)     KJ/KG-MOL      K
OXIDANT     H2O(L)                   0.3333333        0.000      0.000
OXIDANT     CH3OH(L)                 0.3333333        0.000      0.000
OXIDANT     NH3(L)                   0.3333333     -71555.000   239.720
FUEL        RP-1                     1.0000000     -24717.700   298.150
```

O/F=   2.00000 %FUEL= 33.333333 R,EQ.RATIO= 6.777349 PHI,EQ.RATIO=-1.757209

```
              CHAMBER    THROAT
Pinf/P         1.0000    1.8036
```

FileEditor:LMP103S0907.out

```
P, BAR             30.000   16.634
T, K              1175.18  1045.95
RHO, KG/CU M    4.0504 0 2.5232 0
H, KJ/KG         -1523.20 -1935.68
U, KJ/KG         -2263.87 -2594.90
G, KJ/KG         -18743.8 -17262.6
S, KJ/(KG)(K)     14.6535  14.6535


M, (1/n)          13.192   13.192
MW, MOL WT        12.104   12.104
Cp, KJ/(KG)(K)     3.2450   3.1371
GAMMAs             1.2410   1.2514
SON VEL,M/SEC      958.7    908.3
MACH NUMBER        0.000    1.000
```

PERFORMANCE PARAMETERS

```
Ae/At                      1.0000
CSTAR, M/SEC               1309.0
CF                         0.6939
Ivac, M/SEC                1634.1
Isp, M/SEC                  908.3
```

MOLE FRACTIONS

```
CH4          0.14319  *CO      0.13158  *CO2     0.01530
C2H4         0.00001  C2H6     0.00003  HCN      0.00001
*H2          0.47703  H2O      0.07108  NH3      0.00065
*N2          0.07864  C(gr)    0.08248
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

    PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
    WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

O/F =   4.000000

```
                  EFFECTIVE FUEL    EFFECTIVE OXIDANT       MIXTURE
ENTHALPY               h(2)/R             h(1)/R            h0/R
(KG-MOL)(K)/KG    -0.21270751E+03    -0.16844346E+03   -0.17729627E+03


KG-FORM.WT./KG        bi(2)              bi(1)             b0i
 *H               0.13952307E+00     0.13733597E+00    0.13777339E+00
 *O               0.00000000E+00     0.28905870E-01    0.23124696E-01
 *C               0.71550294E-01     0.10403058E-01    0.22632505E-01
 *N               0.00000000E+00     0.19572704E-01    0.15658164E-01

POINT ITN      T          H          O          C          N
```

```
   1    4    1195.905      -7.783      -34.091      -1.795      -12.370

 REMOVE  C(gr)
   1    3    1199.482      -7.766      -33.855      -2.100      -12.377
```

```
            THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

 Pin =   290.1 PSIA
 CASE = LMP130S

              REACTANT                  WT FRACTION      ENERGY       TEMP
                                        (SEE NOTE)     KJ/KG-MOL       K
 OXIDANT      H2O(L)                     0.3333333        0.000       0.000
 OXIDANT      CH3OH(L)                   0.3333333        0.000       0.000
 OXIDANT      NH3(L)                     0.3333333    -71555.000     239.720
 FUEL         RP-1                       1.0000000    -24717.700     298.150

 O/F=    4.00000  %FUEL= 20.000000  R,EQ.RATIO= 4.936355   PHI,EQ.RATIO=-0.878605

               CHAMBER    THROAT
 Pinf/P          1.0000    1.8345
 P, BAR          20.000    10.902
 T, K           1199.48   1044.32
 RHO, KG/CU M   2.3361 0  1.4626 0
 H, KJ/KG      -1474.13  -1959.43
 U, KJ/KG      -2330.27  -2704.83
 G, KJ/KG      -20884.7  -18859.1
 S, KJ/(KG)(K)  16.1824   16.1824

 M, (1/n)        11.649    11.649
 MW, MOL WT      11.649    11.649
 Cp, KJ/(KG)(K)  3.1784    3.0762
 GAMMAs          1.2896    1.3021
 SON VEL,M/SEC   1050.8     985.2
 MACH NUMBER      0.000     1.000

 PERFORMANCE PARAMETERS

 Ae/At                      1.0000
 CSTAR, M/SEC               1388.0
 CF                         0.7098
 Ivac, M/SEC                1741.8
 Isp, M/SEC                  985.2

 MOLE FRACTIONS

 CH4         0.07836    *CO        0.17031    *CO2       0.01492
 C2H6        0.00001    HCN        0.00002    *H2        0.57571
 H2O         0.06922    NH3        0.00051    *N2        0.09094

  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K
```

```
     PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
     WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS




NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS




POINT ITN    T           H          O          C          N

  1    3    1216.654    -7.678    -33.467    -2.159    -12.283




          THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   362.6 PSIA
CASE = LMP130S

              REACTANT                WT FRACTION    ENERGY      TEMP
                                      (SEE NOTE)    KJ/KG-MOL     K
OXIDANT      H2O(L)                   0.3333333        0.000     0.000
OXIDANT      CH3OH(L)                 0.3333333        0.000     0.000
OXIDANT      NH3(L)                   0.3333333    -71555.000   239.720
FUEL         RP-1                     1.0000000    -24717.700   298.150

O/F=    4.00000  %FUEL= 20.000000  R,EQ.RATIO= 4.936355  PHI,EQ.RATIO=-0.878605

                 CHAMBER   THROAT
Pinf/P            1.0000    1.8324
P, BAR            25.000   13.643
T, K             1216.65   1060.85
RHO, KG/CU M     2.8954 0  1.8121 0
H, KJ/KG        -1474.13  -1963.01
U, KJ/KG        -2337.58  -2715.89
G, KJ/KG        -20969.3  -18961.7
S, KJ/(KG)(K)    16.0236   16.0236

M, (1/n)          11.716    11.716
MW, MOL WT        11.716    11.716
Cp, KJ/(KG)(K)    3.1890    3.0857
GAMMAs            1.2862    1.2987
SON VEL,M/SEC     1053.9     988.8
MACH NUMBER       0.000     1.000

PERFORMANCE PARAMETERS

Ae/At                        1.0000
CSTAR, M/SEC                 1395.2
```

FileEditor:LMP103S0907.out

```
CF                      0.7087
Ivac, M/SEC             1750.2
Isp, M/SEC               988.8
```

MOLE FRACTIONS

```
CH4             0.08164  *CO          0.16855  *CO2           0.01492
C2H4            0.00001  C2H6         0.00001  HCN            0.00002
*H2             0.57032  H2O          0.07254  NH3            0.00058
*N2             0.09142
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

    PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
    WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

POINT	ITN	T	H	O	C	N
1	3	1230.993	-7.607	-33.152	-2.207	-12.206

        THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   435.1 PSIA
CASE = LMP130S

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	RP-1	1.0000000	-24717.700	298.150

O/F=   4.00000 %FUEL= 20.000000 R,EQ.RATIO= 4.936355 PHI,EQ.RATIO=-0.878605

```
                CHAMBER   THROAT
Pinf/P           1.0000   1.8307
P, BAR           30.000   16.387
T, K             1230.99  1074.69
RHO, KG/CU M   3.4506 0 2.1590 0
H, KJ/KG        -1474.13 -1965.92
U, KJ/KG        -2343.55 -2724.95
G, KJ/KG        -21040.2 -19047.7
S, KJ/(KG)(K)   15.8945  15.8945
```

```
M, (1/n)           11.772   11.772
MW, MOL WT         11.772   11.772
Cp, KJ/(KG)(K)     3.1979   3.0938
GAMMAs             1.2835   1.2958
SON VEL,M/SEC      1056.3   991.8
MACH NUMBER        0.000    1.000
```

PERFORMANCE PARAMETERS

```
Ae/At                      1.0000
CSTAR, M/SEC               1401.1
CF                         0.7078
Ivac, M/SEC                1757.1
Isp, M/SEC                  991.8
```

MOLE FRACTIONS

```
CH4          0.08441  *CO        0.16706  *CO2       0.01491
C2H4         0.00001  C2H6       0.00001  HCN        0.00002
*H2          0.56575  H2O        0.07535  NH3        0.00064
*N2          0.09183
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

O/F =   6.000000

```
                    EFFECTIVE FUEL     EFFECTIVE OXIDANT       MIXTURE
ENTHALPY                h(2)/R             h(1)/R             h0/R
(KG-MOL)(K)/KG     -0.21270751E+03    -0.16844346E+03    -0.17476690E+03


KG-FORM.WT./KG          bi(2)              bi(1)              b0i
 *H               0.13952307E+00     0.13733597E+00     0.13764841E+00
 *O               0.00000000E+00     0.28905870E-01     0.24776460E-01
 *C               0.71550294E-01     0.10403058E-01     0.19138378E-01
 *N               0.00000000E+00     0.19572704E-01     0.16776604E-01


POINT ITN     T          H          O          C          N

  1    5   1239.522     -7.781    -32.967     -2.770    -12.412
```

FileEditor:LMP103S0907.out

```
                   THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

 Pin =   290.1 PSIA
 CASE = LMP130S


             REACTANT                    WT FRACTION      ENERGY      TEMP
                                         (SEE NOTE)      KJ/KG-MOL     K
 OXIDANT      H2O(L)                      0.3333333        0.000      0.000
 OXIDANT      CH3OH(L)                    0.3333333        0.000      0.000
 OXIDANT      NH3(L)                      0.3333333     -71555.000   239.720
 FUEL         RP-1                        1.0000000     -24717.700   298.150

 O/F=    6.00000  %FUEL= 14.285714  R,EQ.RATIO= 4.322690  PHI,EQ.RATIO=-0.585736

                   CHAMBER   THROAT
 Pinf/P             1.0000   1.8461
 P, BAR             20.000   10.834
 T, K              1239.52  1070.26
 RHO, KG/CU M      2.1580 0 1.3538 0
 H, KJ/KG         -1453.10 -1981.74
 U, KJ/KG         -2379.87 -2781.94
 G, KJ/KG         -22148.4 -19851.0
 S, KJ/(KG)(K)     16.6962  16.6962


 M, (1/n)           11.120   11.120
 MW, MOL WT         11.120   11.120
 Cp, KJ/(KG)(K)     3.1704   3.0752
 GAMMAs             1.3086   1.3212
 SON VEL,M/SEC      1101.3   1028.2
 MACH NUMBER        0.000    1.000

 PERFORMANCE PARAMETERS

 Ae/At              1.0000
 CSTAR, M/SEC       1436.7
 CF                 0.7157
 Ivac, M/SEC        1806.5
 Isp, M/SEC         1028.2

 MOLE FRACTIONS

 CH4        0.03548   *CO        0.16271   *CO2       0.01462
 HCN        0.00001   *H2        0.61008   H2O        0.08359
 NH3        0.00047   *N2        0.09304

  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

    PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
    WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS



 NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS
```

```
 POINT ITN      T          H          O          C          N

   1    3    1256.464    -7.692    -32.614    -2.804    -12.318
```

          THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   362.6 PSIA
CASE = LMP130S

```
               REACTANT              WT FRACTION     ENERGY      TEMP
                                     (SEE NOTE)     KJ/KG-MOL     K
OXIDANT    H2O(L)                    0.3333333        0.000     0.000
OXIDANT    CH3OH(L)                  0.3333333        0.000     0.000
OXIDANT    NH3(L)                    0.3333333    -71555.000   239.720
FUEL       RP-1                      1.0000000    -24717.700   298.150
```

O/F=   6.00000 %FUEL= 14.285714 R,EQ.RATIO= 4.322690 PHI,EQ.RATIO=-0.585736

```
                  CHAMBER    THROAT
Pinf/P            1.0000    1.8441
P, BAR            25.000    13.557
T, K              1256.46   1086.46
RHO, KG/CU M   2.6756 0  1.6779 0
H, KJ/KG         -1453.10  -1985.50
U, KJ/KG         -2387.48  -2793.46
G, KJ/KG         -22222.2  -19944.4
S, KJ/(KG)(K)     16.5298   16.5298

M, (1/n)          11.181    11.181
MW, MOL WT        11.181    11.181
Cp, KJ/(KG)(K)    3.1796    3.0829
GAMMAs            1.3053    1.3179
SON VEL,M/SEC     1104.4    1031.9
MACH NUMBER       0.000     1.000
```

PERFORMANCE PARAMETERS

```
Ae/At                       1.0000
CSTAR, M/SEC                1443.9
CF                          0.7147
Ivac, M/SEC                 1814.9
Isp, M/SEC                  1031.9
```

MOLE FRACTIONS

```
CH4        0.03834   *CO      0.16108   *CO2       0.01453
HCN        0.00002   *H2      0.60511   H2O        0.08687
NH3        0.00054   *N2      0.09351
```

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

POINT	ITN	T	H	O	C	N
1	3	1270.682	-7.620	-32.326	-2.833	-12.241

         THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   435.1 PSIA
CASE = LMP130S

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	RP-1	1.0000000	-24717.700	298.150

O/F=   6.00000 %FUEL= 14.285714 R,EQ.RATIO= 4.322690 PHI,EQ.RATIO=-0.585736

	CHAMBER	THROAT
Pinf/P	1.0000	1.8424
P, BAR	30.000	16.283
T, K	1270.68	1100.09
RHO, KG/CU M	3.1893 0	1.9995 0
H, KJ/KG	-1453.10	-1988.59
U, KJ/KG	-2393.75	-2802.95
G, KJ/KG	-22285.3	-20024.1
S, KJ/(KG)(K)	16.3945	16.3945
M, (1/n)	11.232	11.232
MW, MOL WT	11.232	11.232
Cp, KJ/(KG)(K)	3.1874	3.0897
GAMMAs	1.3025	1.3151
SON VEL,M/SEC	1106.9	1034.9
MACH NUMBER	0.000	1.000

PERFORMANCE PARAMETERS

Ae/At   1.0000

```
CSTAR, M/SEC              1449.8
CF                        0.7138
Ivac, M/SEC              1821.8
Isp, M/SEC              1034.9
```

MOLE FRACTIONS

CH4	0.04077	*CO	0.15969	*CO2	0.01447
HCN	0.00002	*H2	0.60089	H2O	0.08966
NH3	0.00060	*N2	0.09390		

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

O/F =   8.000000

	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL)(K)/KG	-0.21270751E+03	-0.16844346E+03	-0.17336169E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*H	0.13952307E+00	0.13733597E+00	0.13757898E+00
*O	0.00000000E+00	0.28905870E-01	0.25694107E-01
*C	0.71550294E-01	0.10403058E-01	0.17197195E-01
*N	0.00000000E+00	0.19572704E-01	0.17397959E-01

POINT	ITN	T	H	O	C	N
1	4	1279.794	-7.814	-32.150	-3.376	-12.450

          THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   290.1 PSIA
CASE = LMP130S

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	RP-1	1.0000000	-24717.700	298.150

FileEditor:LMP103S0907.out

O/F=   8.00000 %FUEL= 11.111111 R,EQ.RATIO= 4.015858 PHI,EQ.RATIO=-0.439302

```
                CHAMBER   THROAT
Pinf/P            1.0000   1.8508
P, BAR            20.000   10.806
T, K             1279.79  1101.33
RHO, KG/CU M    2.0500 0 1.2871 0
H, KJ/KG        -1441.42 -1999.31
U, KJ/KG        -2417.03 -2838.87
G, KJ/KG        -23152.7 -20683.0
S, KJ/(KG)(K)    16.9647  16.9647


M, (1/n)         10.907   10.907
MW, MOL WT       10.907   10.907
Cp, KJ/(KG)(K)    3.1721   3.0794
GAMMAs            1.3163   1.3290
SON VEL,M/SEC    1133.2   1056.3
MACH NUMBER       0.000    1.000
```

PERFORMANCE PARAMETERS

```
Ae/At             1.0000
CSTAR, M/SEC      1471.0
CF                0.7181
Ivac, M/SEC      1851.1
Isp, M/SEC       1056.3
```

MOLE FRACTIONS

```
CH4      0.01615  *CO     0.15721  *CO2    0.01419
HCN      0.00001  *H2     0.62271  H2O     0.09464
NH3      0.00041  *N2     0.09467
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS


```
POINT ITN    T          H         O         C         N

  1    3   1294.862   -7.722   -31.858   -3.368   -12.353
```

FileEditor:LMP103S0907.out

```
                  THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

 Pin =   362.6 PSIA
 CASE = LMP130S

                 REACTANT                 WT FRACTION      ENERGY       TEMP
                                          (SEE NOTE)     KJ/KG-MOL       K
 OXIDANT      H2O(L)                       0.3333333        0.000       0.000
 OXIDANT      CH3OH(L)                     0.3333333        0.000       0.000
 OXIDANT      NH3(L)                       0.3333333    -71555.000     239.720
 FUEL         RP-1                         1.0000000    -24717.700     298.150

 O/F=    8.00000  %FUEL= 11.111111  R,EQ.RATIO= 4.015858  PHI,EQ.RATIO=-0.439302

                 CHAMBER   THROAT
 Pinf/P           1.0000   1.8490
 P, BAR           25.000   13.521
 T, K            1294.86  1115.73
 RHO, KG/CU M   2.5446 0  1.5972 0
 H, KJ/KG       -1441.42 -2002.69
 U, KJ/KG       -2423.87 -2849.23
 G, KJ/KG       -23188.6 -20741.3
 S, KJ/(KG)(K)   16.7950  16.7950

 M, (1/n)         10.958   10.958
 MW, MOL WT       10.958   10.958
 Cp, KJ/(KG)(K)   3.1799   3.0859
 GAMMAs           1.3134   1.3260
 SON VEL,M/SEC    1135.9   1059.5
 MACH NUMBER       0.000    1.000

 PERFORMANCE PARAMETERS

 Ae/At                     1.0000
 CSTAR, M/SEC              1477.4
 CF                        0.7172
 Ivac, M/SEC              1858.5
 Isp, M/SEC               1059.5

 MOLE FRACTIONS

 CH4            0.01855   *CO         0.15578   *CO2          0.01410
 HCN            0.00001   *H2         0.61841   H2O           0.09758
 NH3            0.00048   *N2         0.09508

  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

    PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
    WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS


 NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS
```

```
 POINT ITN     T          H          O          C          N

   1   3   1307.750     -7.648     -31.613     -3.366     -12.274
```

THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   435.1 PSIA
CASE = LMP130S

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	RP-1	1.0000000	-24717.700	298.150

O/F=   8.00000 %FUEL= 11.111111 R,EQ.RATIO= 4.015858 PHI,EQ.RATIO=-0.439302

```
                  CHAMBER   THROAT
Pinf/P            1.0000    1.8475
P, BAR            30.000    16.238
T, K              1307.75   1128.07
RHO, KG/CU M      3.0358 0  1.9049 0
H, KJ/KG          -1441.42  -2005.52
U, KJ/KG          -2429.63  -2857.96
G, KJ/KG          -23224.5  -20795.7
S, KJ/(KG)(K)     16.6569   16.6569

M, (1/n)          11.003    11.003
MW, MOL WT        11.003    11.003
Cp, KJ/(KG)(K)    3.1866    3.0916
GAMMAs            1.3109    1.3235
SON VEL,M/SEC     1138.2    1062.2
MACH NUMBER       0.000     1.000
```

PERFORMANCE PARAMETERS

```
Ae/At              1.0000
CSTAR, M/SEC       1482.7
CF                 0.7164
Ivac, M/SEC        1864.7
Isp, M/SEC         1062.2
```

MOLE FRACTIONS

```
CH4      0.02063   *CO     0.15454   *CO2    0.01402
HCN      0.00002   *H2     0.61469   H2O     0.10012
NH3      0.00054   *N2     0.09544
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

O/F = 10.000000

	EFFECTIVE FUEL	EFFECTIVE OXIDANT	MIXTURE
ENTHALPY	h(2)/R	h(1)/R	h0/R
(KG-MOL)(K)/KG	-0.21270751E+03	-0.16844346E+03	-0.17246747E+03

KG-FORM.WT./KG	bi(2)	bi(1)	b0i
*H	0.13952307E+00	0.13733597E+00	0.13753480E+00
*O	0.00000000E+00	0.28905870E-01	0.26278064E-01
*C	0.71550294E-01	0.10403058E-01	0.15961898E-01
*N	0.00000000E+00	0.19572704E-01	0.17793368E-01

POINT	ITN	T	H	O	C	N
1	4	1323.662	-7.859	-31.325	-3.989	-12.491

        THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   290.1 PSIA
CASE = LMP130S

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	RP-1	1.0000000	-24717.700	298.150

O/F=   10.00000 %FUEL= 9.090909 R,EQ.RATIO= 3.831759 PHI,EQ.RATIO=-0.351442

	CHAMBER	THROAT
Pinf/P	1.0000	1.8518
P, BAR	20.000	10.800
T, K	1323.66	1138.27
RHO, KG/CU M	1.9691 0	1.2365 0
H, KJ/KG	-1433.98	-2015.13
U, KJ/KG	-2449.70	-2888.59
G, KJ/KG	-24101.9	-21508.2
S, KJ/(KG)(K)	17.1251	17.1251

```
M, (1/n)          10.835   10.835
MW, MOL WT        10.835   10.835
Cp, KJ/(KG)(K)    3.1807   3.0881
GAMMAs            1.3180   1.3306
SON VEL,M/SEC     1157.0   1078.1
MACH NUMBER        0.000    1.000
```

PERFORMANCE PARAMETERS

```
Ae/At                    1.00000
CSTAR, M/SEC             1500.3
CF                       0.7186
Ivac, M/SEC              1888.3
Isp, M/SEC               1078.1
```

MOLE FRACTIONS

```
CH4          0.00705  *CO          0.15213  *CO2          0.01375
HCN          0.00001  *H2          0.62539  H2O           0.10509
NH3          0.00035  *N2          0.09622
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

```
POINT ITN     T          H          O          C          N

  1    3   1335.140    -7.762    -31.117    -3.921    -12.390
```

          THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin =   362.6 PSIA
CASE = LMP130S

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	RP-1	1.0000000	-24717.700	298.150

FileEditor:LMP103S0907.out

O/F= 10.00000 %FUEL= 9.090909 R,EQ.RATIO= 3.831759 PHI,EQ.RATIO=-0.351442

```
                   CHAMBER   THROAT
Pinf/P              1.0000   1.8504
P, BAR              25.000   13.510
T, K               1335.14  1149.27
RHO, KG/CU M     2.4489 0 1.5375 0
H, KJ/KG          -1433.98 -2017.64
U, KJ/KG          -2454.84 -2896.38
G, KJ/KG          -24070.2 -21502.7
S, KJ/(KG)(K)      16.9542  16.9542

M, (1/n)           10.874   10.874
MW, MOL WT         10.874   10.874
Cp, KJ/(KG)(K)      3.1865   3.0930
GAMMAs              1.3157   1.3284
SON VEL,M/SEC      1158.9   1080.4
MACH NUMBER         0.000    1.000
```

PERFORMANCE PARAMETERS

```
Ae/At                1.0000
CSTAR, M/SEC         1505.0
CF                   0.7179
Ivac, M/SEC          1893.8
Isp, M/SEC           1080.4
```

MOLE FRACTIONS

```
CH4        0.00884  *CO     0.15104  *CO2    0.01368
HCN        0.00001  *H2     0.62213  H2O     0.10735
NH3        0.00041  *N2     0.09653
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS

```
POINT ITN     T         H         O         C         N

  1   3   1345.480   -7.684   -30.933   -3.876   -12.309
```

           THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

FileEditor:LMP103S0907.out

Pin =   435.1 PSIA
CASE = LMP130S

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	H2O(L)	0.3333333	0.000	0.000
OXIDANT	CH3OH(L)	0.3333333	0.000	0.000
OXIDANT	NH3(L)	0.3333333	-71555.000	239.720
FUEL	RP-1	1.0000000	-24717.700	298.150

O/F=   10.00000 %FUEL= 9.090909 R,EQ.RATIO= 3.831759 PHI,EQ.RATIO=-0.351442

	CHAMBER	THROAT
Pinf/P	1.0000	1.8492
P, BAR	30.000	16.223
T, K	1345.48	1159.20
RHO, KG/CU M	2.9256 0	1.8363 0
H, KJ/KG	-1433.98	-2019.87
U, KJ/KG	-2459.42	-2903.33
G, KJ/KG	-24058.3	-21511.8
S, KJ/(KG)(K)	16.8150	16.8150
M, (1/n)	10.910	10.910
MW, MOL WT	10.910	10.910
Cp, KJ/(KG)(K)	3.1918	3.0976
GAMMAs	1.3137	1.3263
SON VEL,M/SEC	1160.6	1082.5
MACH NUMBER	0.000	1.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1509.2
CF	0.7172
Ivac, M/SEC	1898.6
Isp, M/SEC	1082.5

MOLE FRACTIONS

CH4	0.01046	*CO	0.15005	*CO2	0.01361
HCN	0.00001	*H2	0.61917	H2O	0.10941
NH3	0.00048	*N2	0.09681		

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

   PRODUCTS WHICH WERE CONSIDERED BUT WHOSE MOLE FRACTIONS
   WERE LESS THAN 5.000000E-06 FOR ALL ASSIGNED CONDITIONS

NOTE. WEIGHT FRACTION OF FUEL IN TOTAL FUELS AND OF OXIDANT IN TOTAL OXIDANTS