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         NASA-GLENN CHEMICAL EQUILIBRIUM PROGRAM CEA2, FEBRUARY 5, 2004
                    BY  BONNIE MCBRIDE AND SANFORD GORDON
        REFS: NASA RP-1311, PART I, 1994 AND NASA RP-1311, PART II, 1996

   *******************************************************************************


   ### CEA analysis performed on Sun 11-Dec-2022 21:37:45

   # Problem Type: "Rocket" (Finite Area Combustor)

   prob case=_____7791 ro equilibrium  ions  fac

   !Mass Flux/Chamber Area, kg/sec-sqm:
   mdot=3.834

   # Pressure (1 value):
   p,psia= 250
   # Chamber/Exit Pressure Ratio (1 value):
   pi/p= 18.532

   # Oxidizer/Fuel Wt. ratio (21 values):
   o/f= 1, 1.05, 1.1, 1.15, 1.2, 1.25, 1.3, 1.35, 1.4, 1.45, 1.5, 1.55, 1.6, 1.65,
   1.7, 1.75, 1.8, 1.85, 1.9, 1.95, 2

   # You selected the following fuels and oxidizers:
   reac
   fuel C2H5OH(L)          wt%= 95.0000
   fuel H2O(L)             wt%=  5.0000
   oxid O2(L)              wt%=100.0000

   # You selected these options for output:
   # short version of output
   output short
   # Proportions of any products will be expressed as Mass Fractions.
   output massf
   # Heat will be expressed as siunits
   output siunits
   # Transport properties calculated
   output transport


   # Input prepared by this script:/var/www/sites/cearun.grc.nasa.gov/cgi-bin/CEARU
   N/prepareInputFile.cgi
```

```
### IMPORTANT:  The following line is the end of your CEA input file!
end
```

                        THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

                     COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

 Pin =   250.0 PSIA
 MDOT/Ac =   3.834 (KG/S)/M**2   Pinj/Pinf = 1.000014
 CASE = _____

                    REACTANT   WT FRACTION   ENERGY   TEMP
                                               (SEE NOTE)   KJ/KG-MOL   K
        FUEL   C2H5OH(L)   0.9500000   0.000   0.000
        FUEL   H2O(L)   0.0500000   0.000   0.000
        OXIDANT   O2(L)   1.0000000   -12979.000   90.170

 O/F=   1.00000 %FUEL= 50.000000 R,EQ.RATIO= 1.712772 PHI,EQ.RATIO= 1.979589

                    INJECTOR   COMB END   THROAT   EXIT
 Pinj/P   1.0000   1.0000   1.7447   18.532
 P, BAR   17.237   17.237   9.8794   0.93011
 T, K   3315.55   3315.55   3113.89   2240.38
 RHO, KG/CU M   1.1341 0   1.1340 0   7.0002-1 9.4099-2
 H, KJ/KG   -202.79   -202.81   -1018.26 -3845.59
 U, KJ/KG   -1722.72   -1722.73   -2429.57 -4834.03
 G, KJ/KG   -46328.0   -46328.0   -44338.0 -35013.3
 S, KJ/(KG)(K)   13.9118   13.9118   13.9118   13.9118

 M, (1/n)   18.137   18.137   18.345   18.845
 (dLV/dLP)t   -1.02157   -1.02157   -1.01538 -1.00115
 (dLV/dLT)p   1.3935   1.3935   1.2975   1.0294
 Cp, KJ/(KG)(K)   5.7911   5.7912   5.0846   2.6894
 GAMMAs   1.1523   1.1523   1.1556   1.2087
 SON VEL,M/SEC   1323.4   1323.4   1277.1   1093.0
 MACH NUMBER   0.000   0.004   1.000   2.469

 TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

 VISC,MILLIPOISE   1.0029   1.0029   0.95862   0.75771

  WITH EQUILIBRIUM REACTIONS

 Cp, KJ/(KG)(K)   5.7911   5.7912   5.0846   2.6894
 CONDUCTIVITY   14.9301   14.9301   12.5399   4.0856
 PRANDTL NUMBER   0.3890   0.3890   0.3887   0.4988

  WITH FROZEN REACTIONS

```
Cp, KJ/(KG)(K)      2.4566   2.4566   2.4378   2.3208
CONDUCTIVITY        4.1965   4.1965   3.9438   2.8945
PRANDTL NUMBER      0.5871   0.5871   0.5926   0.6075


PERFORMANCE PARAMETERS

Ae/At                        167.43   1.0000   3.5197
CSTAR, M/SEC                 1928.1   1928.1   1928.1
CF                           0.0024   0.6624   1.3999
Ivac, M/SEC               322824.7   2382.2   3065.4
Isp, M/SEC                      4.7   1277.1   2699.2


MASS FRACTIONS

*CO              0.49330  0.49330  0.48852  0.46498
*CO2             0.13242  0.13242  0.13995  0.17696
COOH             0.00001  0.00001  0.00000  0.00000
*H               0.00246  0.00246  0.00189  0.00020
HCO              0.00002  0.00002  0.00001  0.00000
HO2              0.00001  0.00001  0.00000  0.00000
*H2              0.02588  0.02588  0.02604  0.02809
H2O              0.31567  0.31567  0.32357  0.32902
*O               0.00246  0.00246  0.00131  0.00001
*OH              0.02515  0.02515  0.01727  0.00073
*O2              0.00261  0.00261  0.00143  0.00001


  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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

             THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

            COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR


Pin =    250.0 PSIA
MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000003
CASE = _____

               REACTANT              WT FRACTION    ENERGY      TEMP
                                     (SEE NOTE)    KJ/KG-MOL     K
FUEL       C2H5OH(L)                 0.9500000       0.000      0.000
FUEL       H2O(L)                    0.0500000       0.000      0.000
OXIDANT    O2(L)                     1.0000000    -12979.000   90.170


O/F=   1.05000  %FUEL= 48.780488  R,EQ.RATIO= 1.652647  PHI,EQ.RATIO= 1.885323


               INJECTOR  COMB END  THROAT    EXIT
Pinj/P           1.0000    1.0000   1.7407   18.532
```

```
 P, BAR              17.237   17.237   9.9020   0.93011
 T, K               3357.34  3357.34  3163.86  2326.41
 RHO, KG/CU M       1.1401 0 1.1401 0 7.0354-1 9.2758-2
 H, KJ/KG           -207.75  -207.75 -1016.55 -3859.30
 U, KJ/KG          -1719.58 -1719.58 -2424.01 -4862.02
 G, KJ/KG          -46491.5 -46491.5 -44633.0 -35930.8
 S, KJ/(KG)(K)      13.7858  13.7858  13.7858  13.7858

 M, (1/n)            18.464   18.464   18.690   19.290
 (dLV/dLP)t        -1.02548 -1.02548 -1.01886 -1.00184
 (dLV/dLT)p          1.4619   1.4619   1.3617   1.0458
 Cp, KJ/(KG)(K)      6.2487   6.2487   5.5451   2.8379
 GAMMAs              1.1475   1.1475   1.1493   1.1966
 SON VEL,M/SEC       1317.1   1317.1   1271.8   1095.4
 MACH NUMBER          0.000    0.002    1.000    2.467


 TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


 VISC,MILLIPOISE    1.0189   1.0189   0.97659  0.78432


  WITH EQUILIBRIUM REACTIONS


 Cp, KJ/(KG)(K)      6.2487   6.2487   5.5451   2.8379
 CONDUCTIVITY       15.9066  15.9066  13.6008   4.6523
 PRANDTL NUMBER      0.4003   0.4003   0.3982   0.4784


  WITH FROZEN REACTIONS


 Cp, KJ/(KG)(K)      2.4323   2.4323   2.4152   2.3096
 CONDUCTIVITY        4.1665   4.1665   3.9279   2.9334
 PRANDTL NUMBER      0.5948   0.5948   0.6005   0.6175


 PERFORMANCE PARAMETERS


 Ae/At                        305.20   1.0000   3.5696
 CSTAR, M/SEC                 1926.4   1926.4   1926.4
 CF                           0.0013   0.6602   1.4029
 Ivac, M/SEC                587917.1   2378.5   3073.5
 Isp, M/SEC                      2.6   1271.8   2702.4


 MASS FRACTIONS


 *CO                0.47296  0.47296  0.46759  0.44399
 *CO2               0.14225  0.14225  0.15070  0.18781
 COOH               0.00001  0.00001  0.00001  0.00000
 *H                 0.00256  0.00256  0.00203  0.00029
 HCO                0.00002  0.00002  0.00001  0.00000
 HO2                0.00002  0.00002  0.00001  0.00000
```

```
*H2                0.02328   0.02328   0.02331   0.02498
H2O                0.32094   0.32094   0.32995   0.34148
*O                 0.00344   0.00344   0.00199   0.00002
*OH                0.03039   0.03039   0.02192   0.00141
*O2                0.00411   0.00411   0.00247   0.00002
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

                THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

               COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

```
Pin =   250.0 PSIA
MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000003
CASE = _____
```

```
          REACTANT                  WT FRACTION      ENERGY      TEMP
                                     (SEE NOTE)     KJ/KG-MOL      K
FUEL       C2H5OH(L)                 0.9500000         0.000     0.000
FUEL       H2O(L)                    0.0500000         0.000     0.000
OXIDANT    O2(L)                     1.0000000     -12979.000    90.170
```

O/F=   1.10000 %FUEL= 47.619048 R,EQ.RATIO= 1.596600 PHI,EQ.RATIO= 1.799626

```
                 INJECTOR  COMB END  THROAT    EXIT
Pinj/P            1.0000    1.0000    1.7374   18.532
P, BAR            17.237    17.237    9.9213   0.93011
T, K              3392.52   3392.52   3206.26  2406.89
RHO, KG/CU M     1.1475 0  1.1475 0  7.0790-1 9.1670-2
H, KJ/KG          -212.46   -212.46  -1014.08 -3865.69
U, KJ/KG         -1714.57  -1714.57  -2415.59 -4880.32
G, KJ/KG         -46566.1  -46566.1  -44822.7 -36752.1
S, KJ/(KG)(K)     13.6635   13.6635   13.6635  13.6635


M, (1/n)          18.778    18.778    19.021   19.724
(dLV/dLP)t       -1.02959  -1.02959  -1.02268 -1.00282
(dLV/dLT)p        1.5333    1.5333    1.4318   1.0687
Cp, KJ/(KG)(K)    6.7140    6.7140    6.0351   3.0414
GAMMAs            1.1435    1.1435    1.1439   1.1841
SON VEL,M/SEC     1310.6    1310.6    1266.2   1096.1
MACH NUMBER       0.000     0.002     1.000    2.466
```

TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

```
VISC,MILLIPOISE   1.0332    1.0332    0.99269  0.80974
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```
 WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)    6.7140    6.7140    6.0351    3.0414
CONDUCTIVITY     16.8325   16.8325   14.6313    5.3424
PRANDTL NUMBER    0.4121    0.4121    0.4095    0.4610

 WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)    2.4085    2.4085    2.3929    2.2979
CONDUCTIVITY      4.1333    4.1333    3.9074    2.9684
PRANDTL NUMBER    0.6021    0.6021    0.6079    0.6268

PERFORMANCE PARAMETERS

Ae/At                       314.17    1.0000    3.6173
CSTAR, M/SEC               1923.0    1923.0    1923.0
CF                          0.0013    0.6584    1.4056
Ivac, M/SEC              604167.0    2373.1    3078.4
Isp, M/SEC                    2.5    1266.2    2703.0

MASS FRACTIONS

*CO             0.45336   0.45336   0.44734   0.42288
*CO2            0.15195   0.15195   0.16144   0.19989
COOH            0.00001   0.00001   0.00001   0.00000
*H              0.00263   0.00263   0.00214   0.00041
HCO             0.00002   0.00002   0.00001   0.00000
HO2             0.00003   0.00003   0.00001   0.00000
*H2             0.02098   0.02098   0.02089   0.02210
H2O             0.32458   0.32458   0.33448   0.35209
*O              0.00459   0.00459   0.00286   0.00005
*OH             0.03569   0.03569   0.02682   0.00250
*O2             0.00614   0.00614   0.00400   0.00008

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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

           THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

          COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

Pin =   250.0 PSIA
MDOT/Ac =     3.834 (KG/S)/M**2     Pinj/Pinf =  1.000003
CASE = _____

          REACTANT                 WT FRACTION     ENERGY      TEMP
                                    (SEE NOTE)    KJ/KG-MOL     K
FUEL       C2H5OH(L)                0.9500000       0.000     0.000
```

```
 FUEL        H2O(L)                            0.0500000        0.000        0.000
 OXIDANT     O2(L)                             1.0000000   -12979.000       90.170


 O/F=     1.15000  %FUEL= 46.511628  R,EQ.RATIO= 1.544230  PHI,EQ.RATIO= 1.721382


                   INJECTOR  COMB END   THROAT      EXIT
 Pinj/P             1.0000    1.0000    1.7345    18.532
 P, BAR            17.237    17.237     9.9375    0.93011
 T, K            3421.81   3421.80   3241.79   2480.77
 RHO, KG/CU M    1.1560 0  1.1560 0  7.1297-1  9.0829-2
 H, KJ/KG        -216.95   -216.96  -1011.04  -3865.44
 U, KJ/KG       -1708.05  -1708.06  -2404.85  -4889.47
 G, KJ/KG       -46564.2  -46564.2  -44920.0  -37466.7
 S, KJ/(KG)(K)   13.5447   13.5447   13.5447   13.5447


 M, (1/n)          19.080    19.080    19.338    20.142
 (dLV/dLP)t       -1.03377  -1.03377  -1.02673  -1.00415
 (dLV/dLT)p        1.6058    1.6058    1.5060    1.0997
 Cp, KJ/(KG)(K)    7.1725    7.1725    6.5402    3.3122
 GAMMAs            1.1401    1.1401    1.1394    1.1717
 SON VEL,M/SEC    1303.8    1303.8    1260.2    1095.4
 MACH NUMBER       0.000     0.002     1.000     2.466

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


 VISC,MILLIPOISE   1.0459    1.0459    1.0070    0.83368


  WITH EQUILIBRIUM REACTIONS


 Cp, KJ/(KG)(K)    7.1725    7.1725    6.5402    3.3122
 CONDUCTIVITY     17.7015   17.7015   15.6228    6.1504
 PRANDTL NUMBER    0.4238    0.4238    0.4216    0.4490


  WITH FROZEN REACTIONS


 Cp, KJ/(KG)(K)    2.3854    2.3854    2.3711    2.2858
 CONDUCTIVITY      4.0978    4.0978    3.8831    2.9989
 PRANDTL NUMBER    0.6089    0.6089    0.6149    0.6354


PERFORMANCE PARAMETERS


 Ae/At                     325.39     1.0000    3.6621
 CSTAR, M/SEC             1918.4     1918.4    1918.4
 CF                         0.0012    0.6569    1.4081
 Ivac, M/SEC           624218.8     2366.2    3080.4
 Isp, M/SEC                  2.4     1260.2    2701.3


MASS FRACTIONS
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```
*CO                  0.43454  0.43454  0.42781  0.40167
*CO2                 0.16144  0.16144  0.17202  0.21312
COOH                 0.00001  0.00001  0.00001  0.00000
*H                   0.00266  0.00266  0.00221  0.00053
HCO                  0.00002  0.00002  0.00001  0.00000
HO2                  0.00003  0.00003  0.00002  0.00000
*H2                  0.01895  0.01895  0.01876  0.01947
H2O                  0.32681  0.32681  0.33737  0.36074
H2O2                 0.00001  0.00001  0.00000  0.00000
*O                   0.00588  0.00588  0.00388  0.00013
*OH                  0.04090  0.04090  0.03181  0.00414
*O2                  0.00876  0.00876  0.00609  0.00021
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

              THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

               COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

```
Pin =   250.0 PSIA
MDOT/Ac =      3.834 (KG/S)/M**2      Pinj/Pinf =  1.000003
CASE = _____
```

```
                REACTANT                  WT FRACTION     ENERGY      TEMP
                                          (SEE NOTE)     KJ/KG-MOL     K
FUEL        C2H5OH(L)                     0.9500000        0.000      0.000
FUEL        H2O(L)                        0.0500000        0.000      0.000
OXIDANT     O2(L)                         1.0000000    -12979.000    90.170
```

```
O/F=    1.20000  %FUEL= 45.454545  R,EQ.RATIO= 1.495186  PHI,EQ.RATIO= 1.649658
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```
                INJECTOR  COMB END  THROAT     EXIT
Pinj/P           1.0000    1.0000    1.7322    18.532
P, BAR           17.237    17.237    9.9508    0.93011
T, K            3445.91   3445.91   3271.18   2547.10
RHO, KG/CU M    1.1653 0  1.1653 0  7.1862-1  9.0229-2
H, KJ/KG        -221.24   -221.24  -1007.59  -3859.24
U, KJ/KG       -1700.35  -1700.36  -2392.30  -4890.08
G, KJ/KG       -46497.9  -46497.9  -44937.8  -38065.4
S, KJ/(KG)(K)   13.4294   13.4294   13.4294   13.4294

M, (1/n)         19.370    19.370    19.642    20.544
(dLV/dLP)t      -1.03790  -1.03790  -1.03090  -1.00594
(dLV/dLT)p       1.6772    1.6772    1.5820    1.1407
Cp, KJ/(KG)(K)   7.6101    7.6101    7.0427    3.6644
GAMMAs           1.1373    1.1373    1.1358    1.1598
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```
SON VEL,M/SEC        1297.0   1297.0   1254.1   1093.4
MACH NUMBER           0.000    0.002    1.000    2.467


TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


VISC,MILLIPOISE    1.0572   1.0572   1.0196   0.85588


 WITH EQUILIBRIUM REACTIONS


Cp, KJ/(KG)(K)     7.6101   7.6101   7.0427   3.6644
CONDUCTIVITY      18.5063  18.5063  16.5646   7.0664
PRANDTL NUMBER     0.4347   0.4347   0.4335   0.4438


 WITH FROZEN REACTIONS


Cp, KJ/(KG)(K)     2.3629   2.3629   2.3496   2.2731
CONDUCTIVITY       4.0607   4.0607   3.8559   3.0243
PRANDTL NUMBER     0.6152   0.6152   0.6213   0.6433


PERFORMANCE PARAMETERS


Ae/At                       339.11   1.0000   3.7028
CSTAR, M/SEC                1912.6   1912.6   1912.6
CF                          0.0012   0.6557   1.4103
Ivac, M/SEC              648599.1   2358.2   3079.6
Isp, M/SEC                     2.3   1254.1   2697.4


MASS FRACTIONS


*CO            0.41648  0.41648  0.40905  0.38044
*CO2           0.17062  0.17062  0.18232  0.22728
COOH           0.00001  0.00001  0.00001  0.00000
*H             0.00266  0.00266  0.00224  0.00066
HCO            0.00002  0.00002  0.00001  0.00000
HO2            0.00005  0.00005  0.00003  0.00000
*H2            0.01716  0.01716  0.01689  0.01709
H2O            0.32785  0.32785  0.33886  0.36733
H2O2           0.00001  0.00001  0.00000  0.00000
*O             0.00727  0.00727  0.00505  0.00027
*OH            0.04590  0.04590  0.03673  0.00639
*O2            0.01198  0.01198  0.00882  0.00053


 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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


         THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM
```

                    COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

   Pin =   250.0 PSIA
   MDOT/Ac =   3.834 (KG/S)/M**2   Pinj/Pinf = 1.000002
   CASE = _____

                  REACTANT   WT FRACTION   ENERGY   TEMP
                                              (SEE NOTE)   KJ/KG-MOL   K
   FUEL   C2H5OH(L)   0.9500000   0.000   0.000
   FUEL   H2O(L)   0.0500000   0.000   0.000
   OXIDANT   O2(L)   1.0000000   -12979.000   90.170

   O/F=   1.25000 %FUEL= 44.444444 R,EQ.RATIO= 1.449161 PHI,EQ.RATIO= 1.583671

                    INJECTOR   COMB END   THROAT   EXIT
   Pinj/P   1.0000   1.0000   1.7303   18.532
   P, BAR   17.237   17.237   9.9618   0.93011
   T, K   3465.52   3465.52   3295.21   2605.11
   RHO, KG/CU M   1.1754 0   1.1754 0 7.2474-1 8.9864-2
   H, KJ/KG   -225.34   -225.34 -1003.84 -3847.86
   U, KJ/KG   -1691.75   -1691.75 -2378.37 -4882.88
   G, KJ/KG   -46378.0   -46378.0 -44888.4 -38541.9
   S, KJ/(KG)(K)   13.3177   13.3177   13.3177   13.3177

   M, (1/n)   19.649   19.649   19.933   20.927
   (dLV/dLP)t   -1.04187   -1.04187 -1.03504 -1.00827
   (dLV/dLT)p   1.7455   1.7455   1.6571   1.1939
   Cp, KJ/(KG)(K)   8.0143   8.0143   7.5247   4.1108
   GAMMAs   1.1351   1.1351   1.1327   1.1487
   SON VEL,M/SEC   1290.1   1290.1   1247.8   1090.4
   MACH NUMBER   0.000   0.002   1.000   2.469

   TRANSPORT PROPERTIES (GASES ONLY)
     CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

   VISC,MILLIPOISE   1.0671   1.0671   1.0307   0.87605

    WITH EQUILIBRIUM REACTIONS

   Cp, KJ/(KG)(K)   8.0143   8.0143   7.5246   4.1108
   CONDUCTIVITY   19.2394   19.2394   17.4447   8.0788
   PRANDTL NUMBER   0.4445   0.4445   0.4446   0.4458

    WITH FROZEN REACTIONS

   Cp, KJ/(KG)(K)   2.3411   2.3411   2.3286   2.2597
   CONDUCTIVITY   4.0227   4.0227   3.8266   3.0441
   PRANDTL NUMBER   0.6210   0.6210   0.6272   0.6503

```
PERFORMANCE PARAMETERS

 Ae/At                       355.68    1.0000    3.7387
 CSTAR, M/SEC                1906.0    1906.0    1906.0
 CF                          0.0011    0.6547    1.4122
 Ivac, M/SEC              677934.2     2349.4    3076.2
 Isp, M/SEC                     2.2    1247.8    2691.7


MASS FRACTIONS

 *CO           0.39920   0.39920   0.39107   0.35939
 *CO2          0.17944   0.17944   0.19222   0.24203
 COOH          0.00001   0.00001   0.00001   0.00000
 *H            0.00263   0.00263   0.00225   0.00077
 HCO           0.00002   0.00002   0.00001   0.00000
 HO2           0.00006   0.00006   0.00003   0.00000
 *H2           0.01559   0.01559   0.01525   0.01498
 H2O           0.32790   0.32790   0.33919   0.37186
 H2O2          0.00001   0.00001   0.00000   0.00000
 *O            0.00872   0.00872   0.00631   0.00053
 *OH           0.05059   0.05059   0.04143   0.00924
 *O2           0.01582   0.01582   0.01221   0.00119


  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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

                THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

             COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR


 Pin =   250.0 PSIA
 MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
 CASE = _____

                REACTANT                WT FRACTION     ENERGY      TEMP
                                        (SEE NOTE)     KJ/KG-MOL      K
 FUEL        C2H5OH(L)                   0.9500000        0.000     0.000
 FUEL        H2O(L)                      0.0500000        0.000     0.000
 OXIDANT     O2(L)                       1.0000000   -12979.000    90.170

 O/F=    1.30000  %FUEL= 43.478261  R,EQ.RATIO= 1.405886  PHI,EQ.RATIO= 1.522761

                INJECTOR  COMB END  THROAT     EXIT
 Pinj/P          1.0000    1.0000   1.7288    18.532
 P, BAR          17.237    17.237   9.9706    0.93011
 T, K           3481.25   3481.25  3314.60   2654.41
 RHO, KG/CU M   1.1861 0  1.1861 0 7.3123-1 8.9722-2
 H, KJ/KG       -229.26   -229.26  -999.87  -3832.08
```

```
U, KJ/KG           -1682.47 -1682.48 -2363.41 -4868.74
G, KJ/KG           -46214.4 -46214.4 -44783.6 -38895.2
S, KJ/(KG)(K)       13.2094  13.2094  13.2094  13.2094


M, (1/n)             19.918   19.918   20.211   21.290
(dLV/dLP)t         -1.04555 -1.04555 -1.03900 -1.01120
(dLV/dLT)p           1.8090   1.8090   1.7290   1.2602
Cp, KJ/(KG)(K)       8.3757   8.3757   7.9703   4.6556
GAMMAs               1.1332   1.1332   1.1303   1.1390
SON VEL,M/SEC        1283.3   1283.3   1241.5   1086.6
MACH NUMBER           0.000    0.002    1.000    2.470

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


VISC,MILLIPOISE     1.0758   1.0758   1.0404   0.89398


 WITH EQUILIBRIUM REACTIONS


Cp, KJ/(KG)(K)       8.3757   8.3757   7.9703   4.6556
CONDUCTIVITY        19.8944  19.8944  18.2512   9.1728
PRANDTL NUMBER       0.4529   0.4529   0.4543   0.4537


 WITH FROZEN REACTIONS


Cp, KJ/(KG)(K)       2.3199   2.3199   2.3082   2.2458
CONDUCTIVITY         3.9843   3.9843   3.7959   3.0578
PRANDTL NUMBER       0.6264   0.6264   0.6326   0.6566


PERFORMANCE PARAMETERS


Ae/At                         378.50   1.0000   3.7692
CSTAR, M/SEC                  1898.8   1898.8   1898.8
CF                            0.0011   0.6538   1.4137
Ivac, M/SEC                718689.8   2339.8   3070.5
Isp, M/SEC                       2.0   1241.5   2684.3

MASS FRACTIONS


*CO                  0.38268  0.38268  0.37390  0.33875
*CO2                 0.18786  0.18786  0.20166  0.25692
COOH                 0.00001  0.00001  0.00001  0.00000
*H                   0.00259  0.00259  0.00223  0.00087
HCO                  0.00002  0.00002  0.00001  0.00000
HO2                  0.00007  0.00007  0.00004  0.00000
*H2                  0.01420  0.01420  0.01382  0.01314
H2O                  0.32716  0.32716  0.33857  0.37443
H2O2                 0.00001  0.00001  0.00001  0.00000
*O                   0.01021  0.01021  0.00764  0.00092
```

```
*OH                  0.05493   0.05493   0.04584   0.01259
*O2                  0.02026   0.02026   0.01626   0.00237
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

                   THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

                 COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

 Pin =   250.0 PSIA
 MDOT/Ac =   3.834 (KG/S)/M**2   Pinj/Pinf = 1.000002
 CASE = _____

               REACTANT   WT FRACTION   ENERGY   TEMP
                                          (SEE NOTE)   KJ/KG-MOL   K
 FUEL   C2H5OH(L)   0.9500000   0.000   0.000
 FUEL   H2O(L)   0.0500000   0.000   0.000
 OXIDANT   O2(L)   1.0000000   -12979.000   90.170

 O/F=   1.35000 %FUEL= 42.553191 R,EQ.RATIO= 1.365120 PHI,EQ.RATIO= 1.466362

                INJECTOR   COMB END   THROAT   EXIT
 Pinj/P   1.0000   1.0000   1.7275   18.532
 P, BAR   17.237   17.237   9.9777   0.93011
 T, K   3493.68   3493.68   3330.02   2695.10
 RHO, KG/CU M   1.1972 0   1.1972 0 7.3801-1 8.9783-2
 H, KJ/KG   -233.01   -233.01   -995.76   -3812.75
 U, KJ/KG   -1672.72   -1672.72 -2347.75 -4848.70
 G, KJ/KG   -46015.5   -46015.5 -44633.6 -39130.3
 S, KJ/(KG)(K)   13.1044   13.1044   13.1044   13.1044

 M, (1/n)   20.176   20.176   20.479   21.631
 (dLV/dLP)t   -1.04889   -1.04889 -1.04269 -1.01468
 (dLV/dLT)p   1.8667   1.8667   1.7956   1.3387
 Cp, KJ/(KG)(K) 8.6890   8.6890   8.3680   5.2856
 GAMMAs   1.1317   1.1317   1.1284   1.1308
 SON VEL,M/SEC   1276.4   1276.4   1235.1   1082.3
 MACH NUMBER   0.000   0.001   1.000   2.472

 TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

 VISC,MILLIPOISE   1.0834   1.0834   1.0488   0.90956

  WITH EQUILIBRIUM REACTIONS

 Cp, KJ/(KG)(K)   8.6890   8.6890   8.3680   5.2856
```

```
CONDUCTIVITY       20.4668   20.4668   18.9743   10.3255
PRANDTL NUMBER      0.4600    0.4600    0.4626    0.4656


  WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)      2.2994    2.2994    2.2883    2.2313
CONDUCTIVITY        3.9458    3.9458    3.7642    3.0654
PRANDTL NUMBER      0.6314    0.6314    0.6376    0.6621


PERFORMANCE PARAMETERS

Ae/At                         403.90    1.0000    3.7943
CSTAR, M/SEC                  1891.0    1891.0    1891.0
CF                            0.0010    0.6532    1.4150
Ivac, M/SEC                 763773.4   2329.7    3062.9
Isp, M/SEC                       1.9   1235.1    2675.7


MASS FRACTIONS

*CO               0.36691   0.36691   0.35753   0.31881
*CO2              0.19585   0.19585   0.21059   0.27145
COOH              0.00001   0.00001   0.00001   0.00000
*H                0.00253   0.00253   0.00220   0.00095
HCO               0.00002   0.00002   0.00001   0.00000
HO2               0.00009   0.00009   0.00005   0.00000
*H2               0.01298   0.01298   0.01256   0.01155
H2O               0.32577   0.32577   0.33720   0.37524
H2O2              0.00001   0.00001   0.00001   0.00000
*O                0.01169   0.01169   0.00899   0.00146
*OH               0.05888   0.05888   0.04989   0.01624
*O2               0.02527   0.02527   0.02096   0.00428


  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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

            THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

          COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR


Pin =   250.0 PSIA
MDOT/Ac =      3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
CASE = _____

               REACTANT                 WT FRACTION      ENERGY      TEMP
                                        (SEE NOTE)     KJ/KG-MOL       K
FUEL       C2H5OH(L)                     0.9500000        0.000      0.000
FUEL       H2O(L)                        0.0500000        0.000      0.000
OXIDANT    O2(L)                         1.0000000   -12979.000     90.170
```

```
 O/F=    1.40000  %FUEL= 41.666667  R,EQ.RATIO= 1.326651  PHI,EQ.RATIO= 1.413992


                   INJECTOR  COMB END   THROAT      EXIT
 Pinj/P              1.0000    1.0000   1.7265    18.532
 P, BAR              17.237    17.237   9.9835   0.93011
 T, K               3503.28   3503.28  3342.09   2727.79
 RHO, KG/CU M      1.2087 0 1.2087 0 7.4501-1 9.0020-2
 H, KJ/KG           -236.61   -236.61  -991.56  -3790.65
 U, KJ/KG          -1662.66  -1662.66 -2331.62  -4823.87
 G, KJ/KG          -45788.5  -45788.5 -44447.6  -39259.2
 S, KJ/(KG)(K)      13.0027   13.0027  13.0027   13.0027


 M, (1/n)            20.426    20.426   20.736    21.951
 (dLV/dLP)t        -1.05184  -1.05184 -1.04600  -1.01859
 (dLV/dLT)p          1.9176    1.9176   1.8557    1.4259
 Cp, KJ/(KG)(K)      8.9519    8.9519   8.7110    5.9676
 GAMMAs              1.1304    1.1304   1.1268    1.1242
 SON VEL,M/SEC       1269.7    1269.7   1228.8    1077.7
 MACH NUMBER          0.000     0.002    1.000     2.474


 TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


 VISC,MILLIPOISE    1.0901    1.0901   1.0561   0.92283


  WITH EQUILIBRIUM REACTIONS


 Cp, KJ/(KG)(K)      8.9519    8.9519   8.7110    5.9676
 CONDUCTIVITY       20.9547   20.9547  19.6071   11.5026
 PRANDTL NUMBER      0.4657    0.4657   0.4692    0.4788


  WITH FROZEN REACTIONS


 Cp, KJ/(KG)(K)      2.2796    2.2796   2.2690    2.2164
 CONDUCTIVITY        3.9075    3.9075   3.7320    3.0670
 PRANDTL NUMBER      0.6359    0.6359   0.6421    0.6669


 PERFORMANCE PARAMETERS


 Ae/At                        309.84    1.0000    3.8143
 CSTAR, M/SEC                 1882.9    1882.9    1882.9
 CF                           0.0013    0.6526    1.4160
 Ivac, M/SEC                583380.7    2319.3    3053.6
 Isp, M/SEC                      2.4    1228.8    2666.1


 MASS FRACTIONS


 *CO                0.35187   0.35187  0.34195   0.29979
```

```
*CO2                0.20339   0.20339   0.21899   0.28525
COOH                0.00001   0.00001   0.00001   0.00000
*H                  0.00246   0.00246   0.00215   0.00100
HCO                 0.00002   0.00002   0.00001   0.00000
HO2                 0.00010   0.00010   0.00006   0.00000
*H2                 0.01189   0.01189   0.01146   0.01019
H2O                 0.32387   0.32387   0.33524   0.37459
H2O2                0.00001   0.00001   0.00001   0.00000
*O                  0.01315   0.01315   0.01034   0.00213
*OH                 0.06243   0.06243   0.05355   0.01996
*O2                 0.03081   0.03081   0.02624   0.00707
```

   * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

                THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

                 COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

```
 Pin =   250.0 PSIA
 MDOT/Ac =    3.834 (KG/S)/M**2     Pinj/Pinf =  1.000002
 CASE = _____
```

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	0.9500000	0.000	0.000
FUEL	H2O(L)	0.0500000	0.000	0.000
OXIDANT	O2(L)	1.0000000	-12979.000	90.170

```
 O/F=    1.45000  %FUEL= 40.816327  R,EQ.RATIO= 1.290291  PHI,EQ.RATIO= 1.365234
```

	INJECTOR	COMB END	THROAT	EXIT
Pinj/P	1.0000	1.0000	1.7257	18.532
P, BAR	17.237	17.237	9.9882	0.93011
T, K	3510.48	3510.48	3351.33	2753.47
RHO, KG/CU M	1.2204 0	1.2204 0	7.5218-1	9.0403-2
H, KJ/KG	-240.05	-240.06	-987.31	-3766.50
U, KJ/KG	-1652.40	-1652.40	-2315.22	-4795.35
G, KJ/KG	-45539.6	-45539.6	-44233.1	-39297.5
S, KJ/(KG)(K)	12.9041	12.9041	12.9041	12.9041
M, (1/n)	20.666	20.666	20.984	22.252
(dLV/dLP)t	-1.05438	-1.05438	-1.04890	-1.02266
(dLV/dLT)p	1.9618	1.9618	1.9083	1.5165
Cp, KJ/(KG)(K)	9.1653	9.1653	8.9968	6.6559
GAMMAs	1.1294	1.1294	1.1255	1.1191
SON VEL,M/SEC	1263.0	1263.0	1222.5	1073.0
MACH NUMBER	0.000	0.002	1.000	2.475

```
TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


VISC,MILLIPOISE   1.0958   1.0958   1.0625  0.93396


 WITH EQUILIBRIUM REACTIONS


Cp, KJ/(KG)(K)    9.1653   9.1653   8.9968   6.6559
CONDUCTIVITY     21.3585  21.3585  20.1462  12.6601
PRANDTL NUMBER    0.4702   0.4702   0.4745   0.4910


 WITH FROZEN REACTIONS


Cp, KJ/(KG)(K)    2.2604   2.2604   2.2502   2.2012
CONDUCTIVITY      3.8696   3.8696   3.6995   3.0635
PRANDTL NUMBER    0.6401   0.6401   0.6462   0.6711


PERFORMANCE PARAMETERS


Ae/At                      313.00   1.0000   3.8300
CSTAR, M/SEC               1874.5   1874.5   1874.5
CF                         0.0013   0.6522   1.4168
Ivac, M/SEC             586717.8   2308.7   3043.1
Isp, M/SEC                    2.4   1222.5   2655.7


MASS FRACTIONS


*CO            0.33753  0.33753  0.32713  0.28184
*CO2           0.21049  0.21049  0.22684  0.29802
COOH           0.00001  0.00001  0.00001  0.00000
*H             0.00238  0.00238  0.00209  0.00103
HCO            0.00001  0.00001  0.00001  0.00000
HO2            0.00012  0.00012  0.00008  0.00001
*H2            0.01093  0.01093  0.01049  0.00904
H2O            0.32157  0.32157  0.33281  0.37279
H2O2           0.00001  0.00001  0.00001  0.00000
*O             0.01455  0.01455  0.01165  0.00291
*OH            0.06558  0.06558  0.05682  0.02356
*O2            0.03682  0.03682  0.03207  0.01079


 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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


          THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM


         COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR
```

```
  Pin =    250.0 PSIA
  MDOT/Ac =      3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
  CASE = _____
```

	REACTANT		WT FRACTION	ENERGY	TEMP
			(SEE NOTE)	KJ/KG-MOL	K
FUEL	C2H5OH(L)		0.9500000	0.000	0.000
FUEL	H2O(L)		0.0500000	0.000	0.000
OXIDANT	O2(L)		1.0000000	-12979.000	90.170

```
  O/F=    1.50000  %FUEL= 40.000000  R,EQ.RATIO= 1.255871  PHI,EQ.RATIO= 1.319726
```

	INJECTOR	COMB END	THROAT	EXIT
Pinj/P	1.0000	1.0000	1.7251	18.532
P, BAR	17.237	17.237	9.9920	0.93011
T, K	3515.66	3515.66	3358.19	2773.25
RHO, KG/CU M	1.2324 0	1.2324 0	7.5947-1	9.0900-2
H, KJ/KG	-243.37	-243.37	-983.04	-3740.90
U, KJ/KG	-1642.05	-1642.05	-2298.70	-4764.12
G, KJ/KG	-45273.8	-45273.8	-43996.5	-39262.2
S, KJ/(KG)(K)	12.8085	12.8085	12.8085	12.8085
M, (1/n)	20.899	20.899	21.223	22.535
(dLV/dLP)t	-1.05651	-1.05651	-1.05137	-1.02664
(dLV/dLT)p	1.9992	1.9992	1.9534	1.6045
Cp, KJ/(KG)(K)	9.3322	9.3322	9.2267	7.3047
GAMMAs	1.1285	1.1285	1.1244	1.1153
SON VEL,M/SEC	1256.3	1256.3	1216.3	1068.3
MACH NUMBER	0.000	0.002	1.000	2.476

```
TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)
```

VISC,MILLIPOISE	1.1008	1.1008	1.0679	0.94318

```
 WITH EQUILIBRIUM REACTIONS
```

Cp, KJ/(KG)(K)	9.3322	9.3322	9.2267	7.3047
CONDUCTIVITY	21.6806	21.6806	20.5917	13.7527
PRANDTL NUMBER	0.4738	0.4738	0.4785	0.5010

```
 WITH FROZEN REACTIONS
```

Cp, KJ/(KG)(K)	2.2418	2.2418	2.2320	2.1858
CONDUCTIVITY	3.8323	3.8323	3.6670	3.0556
PRANDTL NUMBER	0.6440	0.6440	0.6500	0.6747

```
PERFORMANCE PARAMETERS
```

```
 Ae/At                        316.04   1.0000   3.8422
 CSTAR, M/SEC                 1866.0   1866.0   1866.0
 CF                           0.0013   0.6518   1.4174
 Ivac, M/SEC                589742.2   2298.0   3031.7
 Isp, M/SEC                      2.4   1216.3   2644.8
```

MASS FRACTIONS

```
 *CO              0.32387  0.32387  0.31304  0.26501
 *CO2             0.21714  0.21714  0.23417  0.30965
 COOH             0.00001  0.00001  0.00001  0.00000
 *H               0.00230  0.00230  0.00202  0.00104
 HCO              0.00001  0.00001  0.00001  0.00000
 HO2              0.00013  0.00013  0.00009  0.00001
 *H2              0.01007  0.01007  0.00963  0.00807
 H2O              0.31897  0.31897  0.33004  0.37014
 H2O2             0.00001  0.00001  0.00001  0.00000
 *O               0.01588  0.01588  0.01291  0.00375
 *OH              0.06835  0.06835  0.05970  0.02690
 *O2              0.04325  0.04325  0.03838  0.01543
```

  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

                THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

                COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

```
 Pin =   250.0 PSIA
 MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
 CASE = _____
```

```
               REACTANT                 WT FRACTION     ENERGY      TEMP
                                        (SEE NOTE)    KJ/KG-MOL       K
 FUEL        C2H5OH(L)                   0.9500000        0.000     0.000
 FUEL        H2O(L)                      0.0500000        0.000     0.000
 OXIDANT     O2(L)                       1.0000000   -12979.000    90.170
```

```
 O/F=    1.55000  %FUEL= 39.215686  R,EQ.RATIO= 1.223240  PHI,EQ.RATIO= 1.277154
```

```
                 INJECTOR  COMB END  THROAT    EXIT
 Pinj/P           1.0000    1.0000   1.7245   18.532
 P, BAR           17.237    17.237   9.9952   0.93011
 T, K            3519.10   3519.10  3363.03  2788.19
 RHO, KG/CU M   1.2444 0  1.2444 0 7.6684-1 9.1486-2
 H, KJ/KG        -246.55   -246.55  -978.77 -3714.35
 U, KJ/KG       -1631.68  -1631.69 -2282.18 -4731.02
 G, KJ/KG       -44995.2  -44995.2 -43742.9 -39168.9
```

```
 S, KJ/(KG)(K)      12.7159  12.7159  12.7159  12.7159


 M, (1/n)            21.124   21.124   21.453   22.802
 (dLV/dLP)t        -1.05826 -1.05826 -1.05341 -1.03029
 (dLV/dLT)p          2.0301   2.0301   1.9911   1.6851
 Cp, KJ/(KG)(K)      9.4564   9.4564   9.4042   7.8795
 GAMMAs              1.1278   1.1278   1.1236   1.1125
 SON VEL,M/SEC       1249.8   1249.8   1210.1   1063.5
 MACH NUMBER          0.000    0.002    1.000    2.476

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


 VISC,MILLIPOISE    1.1052   1.1052   1.0726  0.95077


  WITH EQUILIBRIUM REACTIONS


 Cp, KJ/(KG)(K)      9.4564   9.4564   9.4042   7.8795
 CONDUCTIVITY       21.9255  21.9255  20.9462  14.7419
 PRANDTL NUMBER      0.4766   0.4766   0.4815   0.5082


  WITH FROZEN REACTIONS


 Cp, KJ/(KG)(K)      2.2239   2.2239   2.2144   2.1705
 CONDUCTIVITY        3.7957   3.7957   3.6347   3.0442
 PRANDTL NUMBER      0.6475   0.6475   0.6534   0.6779

PERFORMANCE PARAMETERS


 Ae/At                        318.94   1.0000   3.8516
 CSTAR, M/SEC                 1857.4   1857.4   1857.4
 CF                           0.0013   0.6515   1.4178
 Ivac, M/SEC                592419.7   2287.2   3019.6
 Isp, M/SEC                      2.3   1210.1   2633.6

MASS FRACTIONS


 *CO                0.31084  0.31084  0.29965  0.24929
 *CO2               0.22337  0.22337  0.24097  0.32011
 COOH               0.00001  0.00001  0.00001  0.00000
 *H                 0.00222  0.00222  0.00195  0.00103
 HCO                0.00001  0.00001  0.00001  0.00000
 HO2                0.00015  0.00015  0.00010  0.00001
 *H2                0.00931  0.00931  0.00886  0.00724
 H2O                0.31613  0.31613  0.32701  0.36688
 H2O2               0.00002  0.00002  0.00001  0.00000
 *O                 0.01714  0.01714  0.01411  0.00460
 *OH                0.07076  0.07076  0.06221  0.02990
 *O2                0.05005  0.05005  0.04511  0.02092
```

```
 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

            THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

            COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

 Pin =   250.0 PSIA
 MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
 CASE = _____
```

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	0.9500000	0.000	0.000
FUEL	H2O(L)	0.0500000	0.000	0.000
OXIDANT	O2(L)	1.0000000	-12979.000	90.170

```
 O/F=    1.60000  %FUEL= 38.461538  R,EQ.RATIO= 1.192262  PHI,EQ.RATIO= 1.237243
```

	INJECTOR	COMB END	THROAT	EXIT
Pinj/P	1.0000	1.0000	1.7241	18.532
P, BAR	17.237	17.237	9.9978	0.93011
T, K	3521.07	3521.07	3366.18	2799.23
RHO, KG/CU M	1.2565 0	1.2565 0	7.7428-1	9.2139-2
H, KJ/KG	-249.61	-249.61	-974.52	-3687.24
U, KJ/KG	-1621.37	-1621.37	-2265.76	-4696.70
G, KJ/KG	-44707.3	-44707.3	-43476.6	-39030.8
S, KJ/(KG)(K)	12.6262	12.6262	12.6262	12.6262
M, (1/n)	21.342	21.342	21.675	23.056
(dLV/dLP)t	-1.05965	-1.05965	-1.05506	-1.03347
(dLV/dLT)p	2.0552	2.0552	2.0218	1.7552
Cp, KJ/(KG)(K)	9.5426	9.5426	9.5342	8.3605
GAMMAs	1.1271	1.1271	1.1228	1.1104
SON VEL,M/SEC	1243.4	1243.4	1204.1	1058.7
MACH NUMBER	0.000	0.002	1.000	2.477

```
 TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)
```

VISC,MILLIPOISE	1.1089	1.1089	1.0765	0.95698

```
  WITH EQUILIBRIUM REACTIONS
```

Cp, KJ/(KG)(K)	9.5426	9.5426	9.5342	8.3605
CONDUCTIVITY	22.0983	22.0983	21.2148	15.6012
PRANDTL NUMBER	0.4788	0.4788	0.4838	0.5128

```
 WITH FROZEN REACTIONS

 Cp, KJ/(KG)(K)     2.2066   2.2066   2.1973   2.1552
 CONDUCTIVITY       3.7598   3.7598   3.6027   3.0301
 PRANDTL NUMBER     0.6508   0.6508   0.6566   0.6807


 PERFORMANCE PARAMETERS

 Ae/At                       321.68   1.0000   3.8589
 CSTAR, M/SEC                1848.8   1848.8   1848.8
 CF                          0.0012   0.6513   1.4182
 Ivac, M/SEC              594729.5   2276.5   3007.1
 Isp, M/SEC                     2.3   1204.1   2622.1


 MASS FRACTIONS

 *CO            0.29843  0.29843  0.28692  0.23463
 *CO2           0.22918  0.22918  0.24728  0.32945
 COOH           0.00001  0.00001  0.00001  0.00000
 *H             0.00213  0.00213  0.00188  0.00101
 HCO            0.00001  0.00001  0.00001  0.00000
 HO2            0.00016  0.00016  0.00011  0.00002
 *H2            0.00863  0.00863  0.00818  0.00653
 H2O            0.31311  0.31311  0.32380  0.36321
 H2O2           0.00002  0.00002  0.00001  0.00000
 *O             0.01832  0.01832  0.01523  0.00545
 *OH            0.07284  0.07284  0.06437  0.03254
 *O2            0.05716  0.05716  0.05220  0.02715


  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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


             THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM


            COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR


 Pin =   250.0 PSIA
 MDOT/Ac =      3.834 (KG/S)/M**2     Pinj/Pinf =  1.000002
 CASE = _____


               REACTANT                WT FRACTION      ENERGY      TEMP
                                       (SEE NOTE)      KJ/KG-MOL      K
 FUEL        C2H5OH(L)                  0.9500000        0.000      0.000
 FUEL        H2O(L)                     0.0500000        0.000      0.000
 OXIDANT     O2(L)                      1.0000000    -12979.000     90.170


 O/F=    1.65000  %FUEL= 37.735849  R,EQ.RATIO= 1.162813  PHI,EQ.RATIO= 1.199751
```

```
                      INJECTOR   COMB END   THROAT      EXIT
 Pinj/P                 1.0000     1.0000    1.7237    18.532
 P, BAR                 17.237     17.237    9.9999   0.93011
 T, K                  3521.79    3521.79   3367.90   2807.13
 RHO, KG/CU M        1.2687 0   1.2687 0  7.8174-1  9.2843-2
 H, KJ/KG              -252.55    -252.55   -970.31  -3659.86
 U, KJ/KG             -1611.14   -1611.15  -2249.50  -4661.67
 G, KJ/KG             -44412.8   -44412.8  -43200.9  -38858.8
 S, KJ/(KG)(K)         12.5391    12.5391   12.5391   12.5391

 M, (1/n)               21.553     21.553    21.891    23.298
 (dLV/dLP)t           -1.06072   -1.06072  -1.05635  -1.03610
 (dLV/dLT)p             2.0750     2.0750    2.0462    1.8135
 Cp, KJ/(KG)(K)         9.5957     9.5957    9.6222    8.7417
 GAMMAs                 1.1266     1.1266    1.1222    1.1088
 SON VEL,M/SEC          1237.2     1237.2    1198.1    1054.0
 MACH NUMBER            0.000      0.002     1.000     2.477
```

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

```
 VISC,MILLIPOISE        1.1120     1.1120    1.0799   0.96202
```

 WITH EQUILIBRIUM REACTIONS

```
 Cp, KJ/(KG)(K)         9.5957     9.5957    9.6222    8.7417
 CONDUCTIVITY          22.2053    22.2053   21.4038   16.3168
 PRANDTL NUMBER         0.4805     0.4805    0.4855    0.5154
```

 WITH FROZEN REACTIONS

```
 Cp, KJ/(KG)(K)         2.1898     2.1898    2.1807    2.1402
 CONDUCTIVITY           3.7247     3.7247    3.5711    3.0139
 PRANDTL NUMBER         0.6538     0.6538    0.6595    0.6831
```

PERFORMANCE PARAMETERS

```
 Ae/At                             324.22    1.0000    3.8646
 CSTAR, M/SEC                      1840.3    1840.3    1840.3
 CF                                0.0012    0.6511    1.4185
 Ivac, M/SEC                     596662.4    2265.8    2994.2
 Isp, M/SEC                           2.3    1198.1    2610.5
```

MASS FRACTIONS

```
 *CO                    0.28661    0.28661   0.27483   0.22097
 *CO2                   0.23459    0.23459   0.25311   0.33774
 COOH                   0.00001    0.00001   0.00001   0.00000
```

```
*H                0.00205   0.00205   0.00181   0.00099
HCO               0.00001   0.00001   0.00001   0.00000
HO2               0.00018   0.00018   0.00012   0.00002
*H2               0.00801   0.00801   0.00758   0.00592
H2O               0.30997   0.30997   0.32044   0.35926
H2O2              0.00002   0.00002   0.00001   0.00000
*O                0.01940   0.01940   0.01626   0.00625
*OH               0.07460   0.07460   0.06622   0.03482
*O2               0.06455   0.06455   0.05960   0.03402
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

              THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

               COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

 Pin =   250.0 PSIA
 MDOT/Ac =   3.834 (KG/S)/M**2   Pinj/Pinf = 1.000002
 CASE = _____

```
              REACTANT                WT FRACTION      ENERGY      TEMP
                                      (SEE NOTE)      KJ/KG-MOL      K
 FUEL         C2H5OH(L)                0.9500000         0.000      0.000
 FUEL         H2O(L)                   0.0500000         0.000      0.000
 OXIDANT      O2(L)                    1.0000000     -12979.000    90.170
```

 O/F=   1.70000 %FUEL= 37.037037 R,EQ.RATIO= 1.134785 PHI,EQ.RATIO= 1.164464

```
                 INJECTOR   COMB END   THROAT     EXIT
 Pinj/P            1.0000     1.0000    1.7234    18.532
 P, BAR           17.237     17.237    10.002    0.93011
 T, K            3521.44    3521.44   3368.40   2812.49
 RHO, KG/CU M    1.2809 0   1.2809 0  7.8922-1  9.3583-2
 H, KJ/KG        -255.38    -255.39   -966.16   -3632.43
 U, KJ/KG       -1601.05   -1601.05  -2233.46  -4626.32
 G, KJ/KG       -44113.9   -44113.9  -42918.6  -38661.1
 S, KJ/(KG)(K)   12.4547    12.4547   12.4547   12.4547

 M, (1/n)         21.758     21.758    22.099    23.528
 (dLV/dLP)t      -1.06150   -1.06150  -1.05730  -1.03819
 (dLV/dLT)p       2.0900     2.0900    2.0649    1.8598
 Cp, KJ/(KG)(K)   9.6202     9.6202    9.6738    9.0266
 GAMMAs           1.1261     1.1261    1.1217    1.1077
 SON VEL,M/SEC   1231.0     1231.0    1192.3    1049.3
 MACH NUMBER      0.000      0.002     1.000     2.477
```

 TRANSPORT PROPERTIES (GASES ONLY)

```
    CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

  VISC,MILLIPOISE   1.1147    1.1147    1.0828   0.96609

   WITH EQUILIBRIUM REACTIONS

  Cp, KJ/(KG)(K)    9.6202    9.6202    9.6738    9.0266
  CONDUCTIVITY     22.2527   22.2527   21.5203   16.8860
  PRANDTL NUMBER    0.4819    0.4819    0.4867    0.5164

   WITH FROZEN REACTIONS

  Cp, KJ/(KG)(K)    2.1736    2.1736    2.1647    2.1253
  CONDUCTIVITY      3.6903    3.6903    3.5400    2.9961
  PRANDTL NUMBER    0.6565    0.6565    0.6621    0.6853

  PERFORMANCE PARAMETERS

  Ae/At                      326.57    1.0000    3.8690
  CSTAR, M/SEC               1831.8    1831.8    1831.8
  CF                         0.0012    0.6509    1.4187
  Ivac, M/SEC             598219.7    2255.2    2981.3
  Isp, M/SEC                    2.2    1192.3    2598.9

  MASS FRACTIONS

  *CO             0.27533   0.27533   0.26333   0.20823
  *CO2            0.23963   0.23963   0.25850   0.34508
  COOH            0.00001   0.00001   0.00001   0.00000
  *H              0.00196   0.00196   0.00174   0.00095
  HCO             0.00001   0.00001   0.00001   0.00000
  HO2             0.00019   0.00019   0.00013   0.00002
  *H2             0.00746   0.00746   0.00703   0.00539
  H2O             0.30674   0.30674   0.31700   0.35515
  H2O2            0.00002   0.00002   0.00001   0.00000
  *O              0.02040   0.02040   0.01722   0.00701
  *OH             0.07609   0.07609   0.06778   0.03675
  *O2             0.07215   0.07215   0.06726   0.04141

   * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

            THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

            COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

  Pin =   250.0 PSIA
  MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
```

```
   CASE = _____
```

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
FUEL	C2H5OH(L)	0.9500000	0.000	0.000
FUEL	H2O(L)	0.0500000	0.000	0.000
OXIDANT	O2(L)	1.0000000	-12979.000	90.170

```
 O/F=    1.75000  %FUEL= 36.363636  R,EQ.RATIO= 1.108076  PHI,EQ.RATIO= 1.131194
```

	INJECTOR	COMB END	THROAT	EXIT
Pinj/P	1.0000	1.0000	1.7231	18.532
P, BAR	17.237	17.237	10.003	0.93011
T, K	3520.17	3520.17	3367.87	2815.79
RHO, KG/CU M	1.2931 0	1.2931 0	7.9669-1	9.4351-2
H, KJ/KG	-258.11	-258.12	-962.06	-3605.11
U, KJ/KG	-1591.10	-1591.10	-2217.66	-4590.91
G, KJ/KG	-43812.5	-43812.5	-42632.0	-38444.3
S, KJ/(KG)(K)	12.3728	12.3728	12.3728	12.3728
M, (1/n)	21.957	21.957	22.302	23.749
(dLV/dLP)t	-1.06203	-1.06203	-1.05797	-1.03975
(dLV/dLT)p	2.1008	2.1008	2.0785	1.8949
Cp, KJ/(KG)(K)	9.6204	9.6204	9.6942	9.2244
GAMMAs	1.1257	1.1257	1.1213	1.1068
SON VEL,M/SEC	1225.0	1225.0	1186.6	1044.6
MACH NUMBER	0.000	0.002	1.000	2.477

```
TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)
```

VISC,MILLIPOISE	1.1169	1.1169	1.0851	0.96933

```
 WITH EQUILIBRIUM REACTIONS
```

Cp, KJ/(KG)(K)	9.6204	9.6204	9.6942	9.2244
CONDUCTIVITY	22.2471	22.2471	21.5717	17.3141
PRANDTL NUMBER	0.4830	0.4830	0.4876	0.5164

```
 WITH FROZEN REACTIONS
```

Cp, KJ/(KG)(K)	2.1579	2.1579	2.1492	2.1108
CONDUCTIVITY	3.6568	3.6568	3.5093	2.9771
PRANDTL NUMBER	0.6591	0.6591	0.6646	0.6873

```
PERFORMANCE PARAMETERS
```

Ae/At		328.73	1.0000	3.8724
CSTAR, M/SEC		1823.4	1823.4	1823.4

```
 CF                         0.0012    0.6507    1.4189
 Ivac, M/SEC             599411.1    2244.7    2968.3
 Isp, M/SEC                   2.2    1186.5    2587.3


 MASS FRACTIONS

 *CO              0.26457   0.26457   0.25239   0.19632
 *CO2             0.24430   0.24430   0.26346   0.35156
 COOH             0.00001   0.00001   0.00001   0.00000
 *H               0.00188   0.00188   0.00167   0.00092
 HCO              0.00001   0.00001   0.00001   0.00000
 HO2              0.00021   0.00021   0.00014   0.00002
 *H2              0.00695   0.00695   0.00654   0.00492
 H2O              0.30346   0.30346   0.31350   0.35094
 H2O2             0.00002   0.00002   0.00001   0.00000
 *O               0.02131   0.02131   0.01808   0.00771
 *OH              0.07732   0.07732   0.06907   0.03836
 *O2              0.07995   0.07995   0.07512   0.04924


  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K


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

             THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

           COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

 Pin =   250.0 PSIA
 MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
 CASE = _____

              REACTANT                WT FRACTION     ENERGY      TEMP
                                      (SEE NOTE)    KJ/KG-MOL      K
 FUEL        C2H5OH(L)                0.9500000        0.000      0.000
 FUEL        H2O(L)                   0.0500000        0.000      0.000
 OXIDANT     O2(L)                    1.0000000    -12979.000     90.170

 O/F=    1.80000  %FUEL= 35.714286  R,EQ.RATIO= 1.082595  PHI,EQ.RATIO= 1.099772


               INJECTOR  COMB END  THROAT     EXIT
 Pinj/P          1.0000    1.0000   1.7229    18.532
 P, BAR          17.237    17.237   10.005   0.93011
 T, K           3518.11   3518.11  3366.45   2817.40
 RHO, KG/CU M   1.3053 0  1.3052 0 8.0415-1 9.5139-2
 H, KJ/KG       -260.75   -260.75  -958.03  -3578.04
 U, KJ/KG      -1581.32  -1581.32 -2202.15  -4555.67
 G, KJ/KG      -43510.0  -43510.0 -42342.8 -38213.2
 S, KJ/(KG)(K)  12.2933   12.2933  12.2933   12.2933
```

```
M, (1/n)            22.151   22.151   22.498   23.961
(dLV/dLP)t         -1.06234 -1.06234 -1.05839 -1.04084
(dLV/dLT)p          2.1080   2.1080   2.0878   1.9200
Cp, KJ/(KG)(K)      9.5999   9.5999   9.6882   9.3464
GAMMAs              1.1254   1.1254   1.1209   1.1062
SON VEL,M/SEC       1219.1   1219.1   1180.9   1039.9
MACH NUMBER          0.000    0.002    1.000    2.477
```

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

```
VISC,MILLIPOISE     1.1188   1.1188   1.0871  0.97187
```

 WITH EQUILIBRIUM REACTIONS

```
Cp, KJ/(KG)(K)      9.5999   9.5999   9.6882   9.3464
CONDUCTIVITY       22.1947  22.1947  21.5655  17.6117
PRANDTL NUMBER      0.4839   0.4839   0.4884   0.5158
```

 WITH FROZEN REACTIONS

```
Cp, KJ/(KG)(K)      2.1427   2.1427   2.1341   2.0965
CONDUCTIVITY        3.6240   3.6240   3.4792   2.9572
PRANDTL NUMBER      0.6615   0.6615   0.6668   0.6890
```

PERFORMANCE PARAMETERS

```
Ae/At                       330.70   1.0000   3.8752
CSTAR, M/SEC                1815.1   1815.1   1815.1
CF                          0.0012   0.6506   1.4191
Ivac, M/SEC              600252.2   2234.4   2955.3
Isp, M/SEC                     2.2   1180.9   2575.8
```

MASS FRACTIONS

```
*CO                 0.25431  0.25431  0.24198  0.18519
*CO2                0.24864  0.24864  0.26803  0.35727
COOH                0.00001  0.00001  0.00001  0.00000
*H                  0.00180  0.00180  0.00160  0.00088
HCO                 0.00001  0.00001  0.00000  0.00000
HO2                 0.00022  0.00022  0.00015  0.00003
*H2                 0.00650  0.00650  0.00610  0.00451
H2O                 0.30014  0.30014  0.30998  0.34669
H2O2                0.00002  0.00002  0.00001  0.00000
*O                  0.02213  0.02213  0.01887  0.00834
*OH                 0.07832  0.07832  0.07012  0.03969
*O2                 0.08789  0.08789  0.08315  0.05740
```

  * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

            THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

          COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR


  Pin =   250.0 PSIA
  MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
  CASE = _____

              REACTANT              WT FRACTION      ENERGY      TEMP
                                    (SEE NOTE)      KJ/KG-MOL      K
  FUEL        C2H5OH(L)             0.9500000         0.000      0.000
  FUEL        H2O(L)                0.0500000         0.000      0.000
  OXIDANT     O2(L)                 1.0000000    -12979.000     90.170

  O/F=    1.85000  %FUEL= 35.087719  R,EQ.RATIO= 1.058260  PHI,EQ.RATIO= 1.070048


                 INJECTOR  COMB END  THROAT     EXIT
  Pinj/P          1.0000    1.0000    1.7227    18.532
  P, BAR          17.237    17.237    10.006   0.93011
  T, K           3515.37   3515.37   3364.26   2817.62
  RHO, KG/CU M   1.3174 0  1.3174 0 8.1158-1 9.5942-2
  H, KJ/KG       -263.29   -263.29   -954.07  -3551.28
  U, KJ/KG      -1571.72  -1571.73  -2186.94  -4520.73
  G, KJ/KG      -43207.6  -43207.6  -42052.4  -37971.7
  S, KJ/(KG)(K)  12.2161   12.2161   12.2161   12.2161

  M, (1/n)        22.339    22.339    22.689    24.165
  (dLV/dLP)t     -1.06246  -1.06246  -1.05859  -1.04153
  (dLV/dLT)p      2.1120    2.1120    2.0933    1.9363
  Cp, KJ/(KG)(K)  9.5622    9.5622    9.6600    9.4045
  GAMMAs          1.1251    1.1251    1.1206    1.1058
  SON VEL,M/SEC   1213.3    1213.3    1175.4    1035.4
  MACH NUMBER     0.000     0.002     1.000     2.477

  TRANSPORT PROPERTIES (GASES ONLY)
    CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

  VISC,MILLIPOISE   1.1203    1.1203    1.0886   0.97382

   WITH EQUILIBRIUM REACTIONS

  Cp, KJ/(KG)(K)   9.5622    9.5622    9.6600    9.4045
  CONDUCTIVITY    22.1012   22.1012   21.5087   17.7919
  PRANDTL NUMBER   0.4847    0.4847    0.4889    0.5147

   WITH FROZEN REACTIONS
```

```
Cp, KJ/(KG)(K)      2.1280   2.1280   2.1196   2.0826
CONDUCTIVITY        3.5919   3.5919   3.4497   2.9367
PRANDTL NUMBER      0.6637   0.6637   0.6689   0.6906
```

PERFORMANCE PARAMETERS

```
Ae/At                        332.48   1.0000   3.8773
CSTAR, M/SEC                 1806.9   1806.9   1806.9
CF                           0.0012   0.6505   1.4192
Ivac, M/SEC                600763.7   2224.3   2942.4
Isp, M/SEC                      2.2   1175.4   2564.4
```

MASS FRACTIONS

```
*CO               0.24452  0.24452  0.23207  0.17476
*CO2              0.25265  0.25265  0.27223  0.36228
COOH              0.00001  0.00001  0.00001  0.00000
*H                0.00173  0.00173  0.00153  0.00084
HCO               0.00001  0.00001  0.00000  0.00000
HO2               0.00024  0.00024  0.00016  0.00003
*H2               0.00608  0.00608  0.00569  0.00415
H2O               0.29682  0.29682  0.30645  0.34244
H2O2              0.00002  0.00002  0.00001  0.00000
*O                0.02287  0.02287  0.01957  0.00890
*OH               0.07910  0.07910  0.07096  0.04076
*O2               0.09595  0.09595  0.09131  0.06584
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

              THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

            COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

```
Pin =   250.0 PSIA
MDOT/Ac =     3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
CASE = _____
```

```
              REACTANT                 WT FRACTION      ENERGY      TEMP
                                       (SEE NOTE)      KJ/KG-MOL      K
FUEL       C2H5OH(L)                    0.9500000        0.000      0.000
FUEL       H2O(L)                       0.0500000        0.000      0.000
OXIDANT    O2(L)                        1.0000000   -12979.000     90.170
```

 O/F=   1.90000 %FUEL= 34.482759 R,EQ.RATIO= 1.034994 PHI,EQ.RATIO= 1.041889

                  INJECTOR   COMB END   THROAT   EXIT

```
 Pinj/P           1.0000    1.0000    1.7225    18.532
 P, BAR           17.237    17.237    10.007    0.93011
 T, K             3512.05   3512.05   3361.42   2816.68
 RHO, KG/CU M     1.3294 0  1.3294 0  8.1898-1  9.6756-2
 H, KJ/KG         -265.74   -265.75   -950.19   -3524.91
 U, KJ/KG         -1562.32  -1562.32  -2172.03  -4486.21
 G, KJ/KG         -42906.2  -42906.2  -41761.9  -37722.8
 S, KJ/(KG)(K)    12.1412   12.1412   12.1412   12.1412


 M, (1/n)         22.522    22.522    22.874    24.362
 (dLV/dLP)t       -1.06241  -1.06241  -1.05860  -1.04187
 (dLV/dLT)p       2.1133    2.1133    2.0955    1.9452
 Cp, KJ/(KG)(K)   9.5100    9.5100    9.6132    9.4096
 GAMMAs           1.1248    1.1248    1.1204    1.1054
 SON VEL,M/SEC    1207.6    1207.6    1170.0    1030.8
 MACH NUMBER      0.000     0.002     1.000     2.477


 TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)


 VISC,MILLIPOISE  1.1215    1.1215    1.0899    0.97526


  WITH EQUILIBRIUM REACTIONS


 Cp, KJ/(KG)(K)   9.5100    9.5100    9.6132    9.4096
 CONDUCTIVITY     21.9722   21.9722   21.4079   17.8688
 PRANDTL NUMBER   0.4854    0.4854    0.4894    0.5136


  WITH FROZEN REACTIONS


 Cp, KJ/(KG)(K)   2.1137    2.1137    2.1054    2.0690
 CONDUCTIVITY     3.5606    3.5606    3.4206    2.9157
 PRANDTL NUMBER   0.6658    0.6658    0.6708    0.6921


 PERFORMANCE PARAMETERS


 Ae/At                      334.08    1.0000    3.8789
 CSTAR, M/SEC               1798.9    1798.9    1798.9
 CF                         0.0012    0.6504    1.4193
 Ivac, M/SEC                600969.8  2214.3    2929.6
 Isp, M/SEC                 2.2       1170.0    2553.1


 MASS FRACTIONS


 *CO              0.23517   0.23517   0.22262   0.16498
 *CO2             0.25636   0.25636   0.27609   0.36668
 COOH             0.00001   0.00001   0.00001   0.00000
 *H               0.00165   0.00165   0.00146   0.00080
 HCO              0.00001   0.00001   0.00000   0.00000
```

```
HO2               0.00025  0.00025  0.00017  0.00003
*H2               0.00571  0.00571  0.00533  0.00382
H2O               0.29349  0.29349  0.30293  0.33821
H2O2              0.00002  0.00002  0.00001  0.00000
*O                0.02352  0.02352  0.02020  0.00939
*OH               0.07970  0.07970  0.07160  0.04159
*O2               0.10409  0.10409  0.09957  0.07449
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

                 THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

                 COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

```
 Pin =    250.0 PSIA
 MDOT/Ac =      3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
 CASE = _____

              REACTANT                 WT FRACTION      ENERGY      TEMP
                                       (SEE NOTE)     KJ/KG-MOL       K
 FUEL        C2H5OH(L)                 0.9500000         0.000      0.000
 FUEL        H2O(L)                    0.0500000         0.000      0.000
 OXIDANT     O2(L)                     1.0000000     -12979.000    90.170

 O/F=    1.95000  %FUEL= 33.898305  R,EQ.RATIO= 1.012730  PHI,EQ.RATIO= 1.015174


                 INJECTOR  COMB END  THROAT     EXIT
 Pinj/P           1.0000    1.0000   1.7224   18.532
 P, BAR           17.237    17.237   10.007   0.93011
 T, K             3508.21   3508.21  3358.02  2814.76
 RHO, KG/CU M   1.3414 0  1.3414 0  8.2634-1 9.7577-2
 H, KJ/KG         -268.11   -268.12  -946.38 -3498.97
 U, KJ/KG        -1553.11  -1553.11 -2157.44 -4452.18
 G, KJ/KG        -42606.5  -42606.5 -41472.2 -37468.6
 S, KJ/(KG)(K)    12.0684   12.0684  12.0684  12.0684


 M, (1/n)         22.700    22.700   23.054   24.552
 (dLV/dLP)t      -1.06222  -1.06222 -1.05845 -1.04192
 (dLV/dLT)p       2.1121    2.1121   2.0948   1.9479
 Cp, KJ/(KG)(K)   9.4460    9.4460   9.5512   9.3714
 GAMMAs           1.1246    1.1246   1.1201   1.1052
 SON VEL,M/SEC    1202.1    1202.1   1164.7   1026.4
 MACH NUMBER      0.000     0.002    1.000    2.477


 TRANSPORT PROPERTIES (GASES ONLY)
   CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)
```

```
 VISC,MILLIPOISE    1.1224    1.1224    1.0908   0.97626

  WITH EQUILIBRIUM REACTIONS

Cp, KJ/(KG)(K)     9.4460    9.4460    9.5512    9.3714
CONDUCTIVITY      21.8125   21.8125   21.2691   17.8564
PRANDTL NUMBER     0.4861    0.4861    0.4898    0.5124

  WITH FROZEN REACTIONS

Cp, KJ/(KG)(K)     2.0999    2.0999    2.0917    2.0557
CONDUCTIVITY       3.5301    3.5301    3.3922    2.8944
PRANDTL NUMBER     0.6677    0.6677    0.6726    0.6934

PERFORMANCE PARAMETERS

Ae/At                       335.52    1.0000    3.8802
CSTAR, M/SEC                1791.0    1791.0    1791.0
CF                          0.0012    0.6503    1.4194
Ivac, M/SEC               600896.0    2204.5    2917.0
Isp, M/SEC                     2.1    1164.7    2542.0

MASS FRACTIONS

*CO               0.22624   0.22624   0.21362   0.15579
*CO2              0.25979   0.25979   0.27962   0.37051
COOH              0.00001   0.00001   0.00001   0.00000
*H                0.00158   0.00158   0.00140   0.00076
HCO               0.00001   0.00001   0.00000   0.00000
HO2               0.00026   0.00026   0.00018   0.00004
*H2               0.00536   0.00536   0.00499   0.00353
H2O               0.29019   0.29019   0.29943   0.33403
H2O2              0.00002   0.00002   0.00001   0.00000
*O                0.02410   0.02410   0.02075   0.00982
*OH               0.08013   0.08013   0.07207   0.04223
*O2               0.11230   0.11230   0.10791   0.08330

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

          THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

          COMPOSITION DURING EXPANSION FROM FINITE AREA COMBUSTOR

Pin =   250.0 PSIA
MDOT/Ac =    3.834 (KG/S)/M**2      Pinj/Pinf =  1.000002
CASE = _____
```

```
            REACTANT              WT FRACTION      ENERGY       TEMP
                                   (SEE NOTE)     KJ/KG-MOL       K
   FUEL        C2H5OH(L)           0.9500000         0.000      0.000
   FUEL        H2O(L)              0.0500000         0.000      0.000
   OXIDANT     O2(L)               1.0000000    -12979.000     90.170
```

O/F=   2.00000 %FUEL= 33.333333 R,EQ.RATIO= 0.991404 PHI,EQ.RATIO= 0.989795

```
                  INJECTOR  COMB END  THROAT     EXIT
Pinj/P             1.0000    1.0000    1.7223    18.532
P, BAR            17.237    17.237    10.008     0.93011
T, K            3503.93    3503.93   3354.12   2812.01
RHO, KG/CU M     1.3533 0   1.3533 0 8.3365-1  9.8404-2
H, KJ/KG         -270.41    -270.41   -942.65  -3473.49
U, KJ/KG        -1544.09   -1544.09  -2143.17  -4418.69
G, KJ/KG       -42309.2   -42309.2  -41184.1  -37210.9
S, KJ/(KG)(K)     11.9976    11.9976   11.9976   11.9976


M, (1/n)          22.873    22.873    23.230    24.736
(dLV/dLP)t        -1.06191  -1.06191  -1.05817  -1.04173
(dLV/dLT)p         2.1090    2.1090    2.0918    1.9453
Cp, KJ/(KG)(K)     9.3721    9.3721    9.4764    9.2984
GAMMAs             1.1244    1.1244    1.1199    1.1051
SON VEL,M/SEC   1196.7    1196.7    1159.5    1022.0
MACH NUMBER        0.000     0.002     1.000     2.477
```

TRANSPORT PROPERTIES (GASES ONLY)
  CONDUCTIVITY IN UNITS OF MILLIWATTS/(CM)(K)

```
VISC,MILLIPOISE   1.1231    1.1231    1.0915    0.97687
```

 WITH EQUILIBRIUM REACTIONS

```
Cp, KJ/(KG)(K)     9.3721    9.3721    9.4764    9.2984
CONDUCTIVITY      21.6267   21.6267   21.0979   17.7679
PRANDTL NUMBER     0.4867    0.4867    0.4903    0.5112
```

 WITH FROZEN REACTIONS

```
Cp, KJ/(KG)(K)     2.0865    2.0865    2.0784    2.0427
CONDUCTIVITY       3.5002    3.5002    3.3643    2.8729
PRANDTL NUMBER     0.6695    0.6695    0.6743    0.6946
```

PERFORMANCE PARAMETERS

```
Ae/At                       336.80    1.0000    3.8811
CSTAR, M/SEC               1783.2    1783.2    1783.2
CF                            0.0012    0.6503    1.4194
Ivac, M/SEC              600569.3    2194.9    2904.5
```

```
  Isp, M/SEC                    2.1   1159.5   2531.0
```

MASS FRACTIONS

```
*CO              0.21770  0.21770  0.20504  0.14714
*CO2             0.26295  0.26295  0.28285  0.37384
COOH             0.00001  0.00001  0.00001  0.00000
*H               0.00151  0.00151  0.00134  0.00072
HCO              0.00001  0.00001  0.00000  0.00000
HO2              0.00027  0.00027  0.00019  0.00004
*H2              0.00504  0.00504  0.00468  0.00327
H2O              0.28691  0.28691  0.29597  0.32991
H2O2             0.00002  0.00002  0.00001  0.00000
*O               0.02461  0.02461  0.02123  0.01019
*OH              0.08041  0.08041  0.07238  0.04268
*O2              0.12054  0.12054  0.11628  0.09222
```

 * THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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