

FileEditor:ethamol-engine-6-frozen.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    o/f=1.5,
           rocket frozen nfz=1
           p,bar=20,
           pi/p=22.222,
react
           fuel=C2H5OH(L) wt=100 t,k=297
           oxid=O2 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

Pc/P = 22.2220

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 | | | | |
| F: C2H5OH(L) | 1.000000 | -0.333921E+05 | 297.00 | 0.0000 |
| C 2.00000 | H 6.00000 | O 1.00000 | | |
| O: O2 | 1.000000 | 0.000000E+00 | 0.00 | 0.0000 |
| O 2.00000 | | | | |

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 |
| 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 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 C2H5OH | g 7/00 CH3OCH3 |
| srd 01 CH3O2CH3 | g 8/00 C2O | tpis79 *C3 |

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| | | | | | |
|--------|------------------|--------|-----------------|--------|-----------------|
| 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 | 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 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-biphenyl | g 8/00 | C12H10,biphenyl | g 6/97 | *H |
| g 1/01 | HCO | g 6/01 | HCCO | 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 | *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 = 1.500000

| ENTHALPY | EFFECTIVE FUEL | EFFECTIVE OXIDANT | MIXTURE | |
|------------------|-----------------|-------------------|-----------------|---------|
| (KG-MOL) (K) /KG | h(2) /R | h(1) /R | h0/R | |
| | -0.72483648E+03 | 0.00000000E+00 | -0.28993459E+03 | |
| KG-FORM.WT./KG | bi(2) | bi(1) | b0i | |
| *C | 0.43413669E-01 | 0.00000000E+00 | 0.17365468E-01 | |
| *H | 0.13024101E+00 | 0.00000000E+00 | 0.52096403E-01 | |
| *O | 0.21706834E-01 | 0.62502344E-01 | 0.46184140E-01 | |
| POINT ITN | T | C | H | O |
| 1 22 | 3232.250 | -15.733 | -10.195 | -16.220 |

THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION

Pin = 290.1 PSIA

CASE =

| REACTANT | WT FRACTION | ENERGY | TEMP |
|----------|-------------|--------|------|
|----------|-------------|--------|------|

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| | | (SEE NOTE) | KJ/KG-MOL | K |
|---------|------------|------------|-------------|---------|
| FUEL | C2H5OH (L) | 1.0000000 | -277638.832 | 297.000 |
| OXIDANT | O2 | 1.0000000 | 0.000 | 0.000 |

O/F= 1.50000 %FUEL= 40.000000 R,EQ.RATIO= 1.316017 PHI,EQ.RATIO= 1.389185

| | CHAMBER | THROAT | EXIT |
|----------------|----------|----------|----------|
| Pinf/P | 1.0000 | 1.7756 | 22.222 |
| P, BAR | 20.000 | 11.264 | 0.90001 |
| T, K | 3232.25 | 2931.80 | 1874.07 |
| RHO, KG/CU M | 1.6399 0 | 1.0182 0 | 1.2728-1 |
| H, KJ/KG | -2410.66 | -3077.87 | -5337.85 |
| U, KJ/KG | -3630.26 | -4184.10 | -6044.97 |
| G, KJ/KG | -41747.5 | -38758.2 | -28145.4 |
| S, KJ/(KG) (K) | 12.1701 | 12.1701 | 12.1701 |

| | | | |
|-----------------|--------|--------|--------|
| M, (1/n) | 22.036 | 22.036 | 22.036 |
| Cp, KJ/(KG) (K) | 2.2341 | 2.2065 | 2.0451 |
| GAMMAS | 1.2032 | 1.2063 | 1.2262 |
| SON VEL,M/SEC | 1211.4 | 1155.2 | 931.2 |
| MACH NUMBER | 0.000 | 1.000 | 2.598 |

PERFORMANCE PARAMETERS

| | | |
|--------------|--------|--------|
| Ae/At | 1.0000 | 3.8194 |
| CSTAR, M/SEC | 1700.4 | 1700.4 |
| CF | 0.6794 | 1.4230 |
| Ivac, M/SEC | 2112.8 | 2711.8 |
| Isp, M/SEC | 1155.2 | 2419.6 |

MOLE FRACTIONS

| | | | | | |
|-----|---------|------|---------|------|---------|
| *CO | 0.24774 | *CO2 | 0.13490 | COOH | 0.00001 |
| *H | 0.02202 | HCO | 0.00001 | HO2 | 0.00002 |
| *H2 | 0.10302 | H2O | 0.44009 | *O | 0.00468 |
| *OH | 0.03970 | *O2 | 0.00780 | | |

* 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