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         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
     rocket  equilibrium  frozen  nfz=2  tcest,k=3800
   p,bar=70,90,120,150,
   sup,ae/at=10,15,20,25,
 react
   oxid=NH4NO3(IV) wt=68  t,k=300
   fuel=AL(cr) wt=18  t,k=300
   name=HTPB  wt=14  t,k=300
     h,kj/mol=-51.8  C 4 H 6
 output
      siunits
 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=T  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 =    70.000000    90.000000   120.000000   150.000000

 Pc/P =

 SUBSONIC AREA RATIOS =

 SUPERSONIC AREA RATIOS =    10.0000    15.0000    20.0000    25.0000

 NFZ=  2  Mdot/Ac= 0.000000E+00  Ac/At= 0.000000E+00

    REACTANT          WT.FRAC    (ENERGY/R),K   TEMP,K  DENSITY
        EXPLODED FORMULA
 O: NH4NO3(IV)       1.000000  -0.439403E+05   300.00  0.0000
          N  2.00000  H  4.00000  O  3.00000
 F: AL(cr)           0.562500   0.538838E+01   300.00  0.0000
          AL 1.00000
 N: HTPB             0.437500  -0.623007E+04   300.00  0.0000
          C  4.00000  H  6.00000

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

  g12/97  *AL              tpis96  ALC             tpis96  ALC2
  tpis96  ALH              tpis96  ALH2            tpis96  ALH3
  tpis96  ALN              tpis96  *ALO            tpis96  ALOH
  tpis96  ALO2             tpis96  AL(OH)2         tpis96  AL(OH)3
  tpis96  AL2              tpis96  AL2C2           tpis96  AL2O
```

tpis96	AL2O2	tpis96	AL2O3	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
tpis96	HALO	tpis96	HALO2	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
coda89	AL(cr)	coda89	AL(L)	tpis96	ALH3(a)
tpis96	ALN(cr)	tpis96	ALN(cr)	tpis96	ALN(L)
tpis96	ALN(L)	tpis96	AL(OH)3(a)	tpis96	AL2O3(a)

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 tpis96  AL2O3(a)         tpis96  AL2O3(a)         tpis96  AL2O3(L)
 tpis96  AL4C3(cr)        tpis96  AL4C3(cr)        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 =   2.125000

                       EFFECTIVE FUEL     EFFECTIVE OXIDANT        MIXTURE
 ENTHALPY                  h(2)/R             h(1)/R                h0/R
 (KG-MOL)(K)/KG       -0.50278394E+02    -0.54895640E+03    -0.38937944E+03

 KG-FORM.WT./KG             bi(2)              bi(1)              b0i
  *N                   0.00000000E+00     0.24986457E-01     0.16990791E-01
  *H                   0.48529833E-01     0.49972915E-01     0.49511128E-01
  *O                   0.00000000E+00     0.37479686E-01     0.25486186E-01
  *AL                  0.20847588E-01     0.00000000E+00     0.66712283E-02
  *C                   0.32353222E-01     0.00000000E+00     0.10353031E-01

 POINT ITN      T           N          H          O          AL
                   C
   1   22    1777.492     -11.958      -7.886     -27.424      -9.748
                -4.547
 ADD  AL2O3(a)
   1    9    2701.690     -12.694      -8.508     -20.590     -18.412
               -10.328
 PHASE CHANGE, REPLACE  AL2O3(a)       WITH  AL2O3(L)
   1    2    2540.867     -12.582      -8.400     -21.190     -19.696
                -9.817
 Pinf/Pt = 1.764183
   2    3    2321.890     -12.706      -8.531     -22.155     -21.128
                -9.592
 ADD  AL2O3(a)
   2    2    2327.000     -12.710      -8.534     -22.130     -21.091
                -9.612
 Pinf/Pt = 1.613671
   2    2    2327.000     -12.665      -8.490     -22.130     -21.091
                -9.523
 REMOVE  AL2O3(a)
   2    2    2355.341     -12.686      -8.510     -21.995     -20.888
                -9.632

 WARNING!!  DISCONTINUITY AT THE THROAT (ROCKET)
 Pinf/Pt = 1.740406
   2    2    2326.957     -12.703      -8.528     -22.131     -21.091
                -9.598
 ADD  AL2O3(a)
   2    1    2327.000     -12.703      -8.528     -22.130     -21.091
                -9.599
   3    5    1490.598     -13.302      -9.158     -28.738     -31.263
                -7.418
 PHASE CHANGE, REPLACE  AL2O3(L)       WITH  AL2O3(a)
   3    2    1584.601     -13.397      -9.250     -27.617     -30.750
                -8.193
   3    4    1283.934     -13.661      -9.522     -31.825     -38.155
                -6.509
   3    2    1291.632     -13.653      -9.514     -31.691     -37.920
                -6.565
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4	3	1175.960	-13.777	-9.639	-33.902	-41.786
		-5.636				
4	0	1175.961	-13.777	-9.639	-33.902	-41.786
		-5.636				
4	2	1169.816	-13.784	-9.646	-34.033	-42.013
		-5.581				
5	3	1085.673	-13.887	-9.748	-35.979	-45.396
		-4.747				
5	2	1091.793	-13.879	-9.740	-35.827	-45.132
		-4.812				
6	3	1041.723	-13.947	-9.808	-37.129	-47.386
		-4.251				
6	2	1036.175	-13.955	-9.815	-37.281	-47.650
		-4.185				

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 1015.3 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT	EXIT	EXIT	EXIT	EXIT
Pinf/P	1.0000	1.7404	77.885	134.08	196.12	262.62
P, BAR	70.000	40.221	0.89876	0.52206	0.35693	0.26655
T, K	2540.87	2327.00	1291.63	1169.82	1091.79	1036.17
RHO, KG/CU M	7.5902 0	4.7650 0	1.9194-1	1.2311-1	9.0200-2	7.0999-2
H, KJ/KG	-3237.50	-3726.62	-6251.94	-6494.11	-6649.89	-6762.45
U, KJ/KG	-4159.74	-4570.70	-6720.19	-6918.17	-7045.60	-7137.87
G, KJ/KG	-29635.0	-27902.2	-19670.9	-18647.5	-17992.7	-17527.4
S, KJ/(KG)(K)	10.3892	10.3892	10.3892	10.3892	10.3892	10.3892
M, (1/n)	22.907	22.922	22.935	22.937	22.940	22.948
MW, MOL WT	21.282	21.294	21.305	21.306	21.310	21.317
(dLV/dLP)t	-1.00082	-1.00042	-1.00008	-1.00023	-1.00057	-1.00124
(dLV/dLT)p	1.0148	0.0000	1.0008	1.0026	1.0072	1.0169
Cp, KJ/(KG)(K)	2.3509	0.0000	1.9914	1.9949	2.0222	2.0799
GAMMAs	1.1879	0.0000	1.2229	1.2232	1.2214	1.2179
SON VEL,M/SEC	1046.7	0.0	756.7	720.2	695.2	676.2
MACH NUMBER	0.000	0.000	3.245	3.544	3.758	3.927

PERFORMANCE PARAMETERS

Ae/At	1.0000	10.000	15.000	20.000	25.000
CSTAR, M/SEC	1485.3	1485.3	1485.3	1485.3	1485.3

CF	0.6659	1.6531	1.7183	1.7589	1.7876
Ivac, M/SEC	1842.5	2646.1	2718.3	2763.9	2796.6
Isp, M/SEC	989.1	2455.4	2552.1	2612.4	2655.2

MOLE FRACTIONS

ALOH	0.00005	0.00001	0.00000	0.00000	0.00000	0.00000
AL(OH)3	0.00002	0.00001	0.00000	0.00000	0.00000	0.00000
CH4	0.00000	0.00000	0.00002	0.00005	0.00013	0.00029
*CO	0.21227	0.21166	0.19803	0.19267	0.18798	0.18379
*CO2	0.00801	0.00877	0.02252	0.02787	0.03251	0.03661
*H	0.00226	0.00110	0.00000	0.00000	0.00000	0.00000
HCN	0.00004	0.00002	0.00000	0.00000	0.00000	0.00000
*H2	0.42444	0.42607	0.44065	0.44593	0.45040	0.45415
H2O	0.10099	0.10036	0.08671	0.08140	0.07686	0.07295
NH3	0.00009	0.00007	0.00002	0.00002	0.00002	0.00002
*NO	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
*N2	0.18073	0.18085	0.18099	0.18100	0.18103	0.18108
*OH	0.00013	0.00005	0.00000	0.00000	0.00000	0.00000
AL2O3(a)	0.00000	0.00002	0.07107	0.07107	0.07108	0.07110
AL2O3(L)	0.07096	0.07100	0.00000	0.00000	0.00000	0.00000

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH
OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl
C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane
C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6
C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCO	HCCN	HCCO	HNC
HNCO	HNO	HNO2	HNO3	HO2
HCHO,formaldehy	HCOOH	H2O2	(HCOOH)2	*N

NCO	*NH	NH2	NH2OH	NO2
NO3	NCN	N2H2	NH2NO2	N2H4
N2O	N2O3	N2O4	N2O5	N3
N3H	*O	*O2	O3	AL(cr)
AL(L)	ALH3(a)	ALN(cr)	ALN(L)	AL(OH)3(a)
AL4C3(cr)	C(gr)	H2O(cr)	H2O(L)	

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

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 1015.3 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7404
P, BAR	70.000	40.221
T, K	2540.87	2327.00
RHO, KG/CU M	7.5902 0	4.7650 0
H, KJ/KG	-3237.50	-3726.62
U, KJ/KG	-4159.74	-4570.70
G, KJ/KG	-29635.0	-27902.2
S, KJ/(KG)(K)	10.3892	10.3892
M, (1/n)	22.907	22.922
MW, MOL WT	21.282	21.294
(dLV/dLP)t	-1.00082	-1.00042
(dLV/dLT)p	1.0148	0.0000
Cp, KJ/(KG)(K)	2.3509	0.0000
GAMMAs	1.1879	0.0000
SON VEL,M/SEC	1046.7	0.0
MACH NUMBER	0.000	0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6659
Ivac, M/SEC	1842.5
Isp, M/SEC	989.1

MOLE FRACTIONS

ALOH	0.00005	0.00001
AL(OH)3	0.00002	0.00001
*CO	0.21227	0.21166
*CO2	0.00801	0.00877
*H	0.00226	0.00110
HCN	0.00004	0.00002
*H2	0.42444	0.42607
H2O	0.10099	0.10036
NH3	0.00009	0.00007
*NO	0.00001	0.00000
*N2	0.18073	0.18085
*OH	0.00013	0.00005
AL2O3(a)	0.00000	0.00002
AL2O3(L)	0.07096	0.07100

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	*CN
CNN	COOH	*C2	C2H	C2H2,acetylene
C2H2,vinylidene	CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl
CH3CN	CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal
CH3COOH	OHCH2COOH	C2H5	C2H6	CH3N2CH3
C2H5OH	CH3OCH3	CH3O2CH3	CCN	CNC
OCCN	C2N2	C2O	*C3	C3H3,1-propynl
C3H3,2-propynl	C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl
C3H6,propylene	C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal
C3H7,n-propyl	C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol
CNCOCN	C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-
C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene
C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2
C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane
C4H10,isobutane	C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HALO	HALO2	HCO	HCCN	HCCO
HNC	HNCO	HNO	HNO2	HNO3
HO2	HCHO,formaldehy	HCOOH	H2O2	(HCOOH)2
*N	NCO	*NH	NH2	NH2OH
NO2	NO3	NCN	N2H2	NH2NO2
N2H4	N2O	N2O3	N2O4	N2O5
N3	N3H	*O	*O2	O3
AL(cr)	AL(L)	ALH3(a)	ALN(cr)	ALN(L)
AL(OH)3(a)	AL4C3(cr)	C(gr)	H2O(cr)	H2O(L)

FileEditor:xEx8.out

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

THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION
AFTER POINT 2

Pin = 1015.3 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7404
P, BAR	70.000	40.221
T, K	2540.87	2327.00
RHO, KG/CU M	7.5902 0	4.7650 0
H, KJ/KG	-3237.50	-3726.62
U, KJ/KG	-4159.74	-4570.70
G, KJ/KG	-29635.0	-27902.2
S, KJ/(KG)(K)	10.3892	10.3892
M, (1/n)	22.907	22.922
MW, MOL WT	21.282	21.294
Cp, KJ/(KG)(K)	2.3509	0.0000
GAMMAs	1.1879	0.0000
SON VEL,M/SEC	1046.7	0.0
MACH NUMBER	0.000	0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6659
Ivac, M/SEC	1842.5
Isp, M/SEC	989.1

MOLE FRACTIONS

ALOH	0.00005	AL(OH)3	0.00002	*CO	0.21239
*CO2	0.00801	*H	0.00226	HCN	0.00004
*H2	0.42468	H2O	0.10105	NH3	0.00009
*NO	0.00001	*N2	0.18083	*OH	0.00013
AL2O3(L)	0.07100				

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	*CN
CNN	COOH	*C2	C2H	C2H2,acetylene
C2H2,vinylidene	CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl
CH3CN	CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal
CH3COOH	OHCH2COOH	C2H5	C2H6	CH3N2CH3
C2H5OH	CH3OCH3	CH3O2CH3	CCN	CNC
OCCN	C2N2	C2O	*C3	C3H3,1-propynl
C3H3,2-propynl	C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl
C3H6,propylene	C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal
C3H7,n-propyl	C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol
CNCOCN	C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-
C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene
C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2
C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane
C4H10,isobutane	C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HALO	HALO2	HCO	HCCN	HCCO
HNC	HNCO	HNO	HNO2	HNO3
HO2	HCHO,formaldehy	HCOOH	H2O2	(HCOOH)2
*N	NCO	*NH	NH2	NH2OH
NO2	NO3	NCN	N2H2	NH2NO2
N2H4	N2O	N2O3	N2O4	N2O5
N3	N3H	*O	*O2	O3
AL(cr)	AL(L)	ALH3(a)	ALN(cr)	ALN(L)
AL(OH)3(a)	AL4C3(cr)	C(gr)	H2O(cr)	H2O(L)

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

POINT	ITN	T	N	H	O	AL
		C				
1	3	2542.255	-12.457	-8.276	-21.184	-19.688
		-9.570				
Pinf/Pt = 1.764536						
2	3	2322.432	-12.580	-8.405	-22.153	-21.124
		-9.343				
ADD AL2O3(a)						
2	2	2327.000	-12.584	-8.409	-22.130	-21.091
		-9.361				
Pinf/Pt = 1.613392						
2	2	2327.000	-12.539	-8.364	-22.130	-21.091
		-9.272				

```
 REMOVE  AL2O3(a)
   2    2    2356.115     -12.561      -8.385     -21.991     -20.883
                -9.384

 WARNING!!  DISCONTINUITY AT THE THROAT (ROCKET)
 Pinf/Pt = 1.743333
   2    2    2326.957     -12.578      -8.403     -22.131     -21.091
                -9.349
 ADD  AL2O3(a)
   2    1    2327.000     -12.578      -8.403     -22.130     -21.091
                -9.349
   3    5    1490.567     -13.176      -9.032     -28.739     -31.264
                -7.166
 PHASE CHANGE, REPLACE  AL2O3(L)       WITH  AL2O3(a)
   3    2    1584.552     -13.271      -9.124     -27.618     -30.751
                -7.941
   3    4    1283.909     -13.535      -9.397     -31.826     -38.156
                -6.258
   3    2    1291.610     -13.528      -9.389     -31.692     -37.921
                -6.313
   4    3    1176.066     -13.651      -9.513     -33.900     -41.783
                -5.387
   4    0    1176.068     -13.651      -9.513     -33.900     -41.783
                -5.387
   4    2    1169.935     -13.658      -9.520     -34.030     -42.010
                -5.331
   5    3    1086.118     -13.762      -9.623     -35.967     -45.379
                -4.504
   5    2    1092.218     -13.754      -9.615     -35.815     -45.115
                -4.569
   6    3    1042.636     -13.823      -9.683     -37.101     -47.347
                -4.018
   6    2    1037.161     -13.831      -9.691     -37.251     -47.607
                -3.954
```

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

```
 Pin =  1305.3 PSIA
 CASE =

            REACTANT                    WT FRACTION      ENERGY      TEMP
                                         (SEE NOTE)     KJ/KG-MOL      K
 OXIDANT    NH4NO3(IV)                   1.0000000   -365342.184    300.000
 FUEL       AL(cr)                       0.5625000        44.802    300.000
 NAME       HTPB                         0.4375000    -51800.000    300.000

 O/F=    2.12500  %FUEL= 32.000000  R,EQ.RATIO= 2.176413  PHI,EQ.RATIO= 4.529239

                CHAMBER   THROAT     EXIT     EXIT     EXIT     EXIT
 Pinf/P           1.0000   1.7433   77.891   134.08   196.08   262.47
 P, BAR           90.000   51.625   1.1555  0.67123  0.45900  0.34290
```

T, K	2542.26	2327.00	1291.61	1169.93	1092.22	1037.16
RHO, KG/CU M	9.7554 0	6.1168 0	2.4677-1	1.5828-1	1.1597-1	9.1285-2
H, KJ/KG	-3237.50	-3728.17	-6252.10	-6494.23	-6649.96	-6762.41
U, KJ/KG	-4160.06	-4572.16	-6720.33	-6918.30	-7045.75	-7138.04
G, KJ/KG	-29417.6	-27691.5	-19553.1	-18542.2	-17897.6	-17443.1
S, KJ/(KG)(K)	10.2980	10.2980	10.2980	10.2980	10.2980	10.2980
M, (1/n)	22.912	22.924	22.935	22.938	22.945	22.957
MW, MOL WT	21.286	21.296	21.305	21.308	21.313	21.324
(dLV/dLP)t	-1.00080	-1.00042	-1.00013	-1.00037	-1.00092	-1.00198
(dLV/dLT)p	1.0133	0.0000	1.0013	1.0043	1.0118	1.0269
Cp, KJ/(KG)(K)	2.3375	0.0000	1.9932	2.0022	2.0433	2.1291
GAMMAs	1.1885	0.0000	1.2228	1.2228	1.2204	1.2157
SON VEL,M/SEC	1047.1	0.0	756.7	720.1	695.0	675.8
MACH NUMBER	0.000	0.000	3.245	3.544	3.759	3.929

PERFORMANCE PARAMETERS

Ae/At	1.0000	10.000	15.000	20.000	25.000
CSTAR, M/SEC	1485.3	1485.3	1485.3	1485.3	1485.3
CF	0.6670	1.6532	1.7183	1.7589	1.7876
Ivac, M/SEC	1842.6	2646.1	2718.3	2764.0	2796.6
Isp, M/SEC	990.6	2455.4	2552.1	2612.5	2655.1

MOLE FRACTIONS

ALOH	0.00004	0.00001	0.00000	0.00000	0.00000	0.00000
AL(OH)3	0.00002	0.00001	0.00000	0.00000	0.00000	0.00000
CH4	0.00000	0.00000	0.00003	0.00008	0.00021	0.00046
*CO	0.21230	0.21167	0.19803	0.19264	0.18794	0.18371
*CO2	0.00801	0.00877	0.02252	0.02787	0.03251	0.03660
*H	0.00200	0.00097	0.00000	0.00000	0.00000	0.00000
HCN	0.00005	0.00003	0.00000	0.00000	0.00000	0.00000
HCO	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
HNC	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
*H2	0.42458	0.42614	0.44063	0.44586	0.45022	0.45376
H2O	0.10104	0.10038	0.08672	0.08144	0.07696	0.07317
NH3	0.00011	0.00008	0.00002	0.00002	0.00002	0.00002
*N2	0.18074	0.18086	0.18099	0.18101	0.18105	0.18115
*OH	0.00011	0.00004	0.00000	0.00000	0.00000	0.00000
AL2O3(a)	0.00000	0.00002	0.07107	0.07107	0.07109	0.07113
AL2O3(L)	0.07097	0.07101	0.00000	0.00000	0.00000	0.00000

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH

OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl
C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane
C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6
C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCCN	HCCO	HNCO	HNO
HNO2	HNO3	HO2	HCHO,formaldehy	HCOOH
H2O2	(HCOOH)2	*N	NCO	*NH
NH2	NH2OH	*NO	NO2	NO3
NCN	N2H2	NH2NO2	N2H4	N2O
N2O3	N2O4	N2O5	N3	N3H
*O	*O2	O3	AL(cr)	AL(L)
ALH3(a)	ALN(cr)	ALN(L)	AL(OH)3(a)	AL4C3(cr)
C(gr)	H2O(cr)	H2O(L)		

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

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 1305.3 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7433
P, BAR	90.000	51.625
T, K	2542.26	2327.00
RHO, KG/CU M	9.7554 0	6.1168 0
H, KJ/KG	-3237.50	-3728.17
U, KJ/KG	-4160.06	-4572.16
G, KJ/KG	-29417.6	-27691.5

S, KJ/(KG)(K)	10.2980	10.2980
M, (1/n)	22.912	22.924
MW, MOL WT	21.286	21.296
(dLV/dLP)t	-1.00080	-1.00042
(dLV/dLT)p	1.0133	0.0000
Cp, KJ/(KG)(K)	2.3375	0.0000
GAMMAs	1.1885	0.0000
SON VEL,M/SEC	1047.1	0.0
MACH NUMBER	0.000	0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6670
Ivac, M/SEC	1842.6
Isp, M/SEC	990.6

MOLE FRACTIONS

ALOH	0.00004	0.00001
AL(OH)3	0.00002	0.00001
*CO	0.21230	0.21167
*CO2	0.00801	0.00877
*H	0.00200	0.00097
HCN	0.00005	0.00003
HCO	0.00001	0.00000
HNC	0.00001	0.00000
*H2	0.42458	0.42614
H2O	0.10104	0.10038
NH3	0.00011	0.00008
*N2	0.18074	0.18086
*OH	0.00011	0.00004
AL2O3(a)	0.00000	0.00002
AL2O3(L)	0.07097	0.07101

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	*CN
CNN	COOH	*C2	C2H	C2H2,acetylene
C2H2,vinylidene	CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl
CH3CN	CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal
CH3COOH	OHCH2COOH	C2H5	C2H6	CH3N2CH3
C2H5OH	CH3OCH3	CH3O2CH3	CCN	CNC
OCCN	C2N2	C2O	*C3	C3H3,1-propynl
C3H3,2-propynl	C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl
C3H6,propylene	C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal
C3H7,n-propyl	C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol

CNCOCN	C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-
C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene
C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2
C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane
C4H10,isobutane	C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HALO	HALO2	HCCN	HCCO	HNCO
HNO	HNO2	HNO3	HO2	HCHO,formaldehy
HCOOH	H2O2	(HCOOH)2	*N	NCO
*NH	NH2	NH2OH	*NO	NO2
NO3	NCN	N2H2	NH2NO2	N2H4
N2O	N2O3	N2O4	N2O5	N3
N3H	*O	*O2	O3	AL(cr)
AL(L)	ALH3(a)	ALN(cr)	ALN(L)	AL(OH)3(a)
AL4C3(cr)	C(gr)	H2O(cr)	H2O(L)	

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

THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION
AFTER POINT 2

Pin = 1305.3 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7433
P, BAR	90.000	51.625
T, K	2542.26	2327.00
RHO, KG/CU M	9.7554 0	6.1168 0
H, KJ/KG	-3237.50	-3728.17
U, KJ/KG	-4160.06	-4572.16
G, KJ/KG	-29417.6	-27691.5
S, KJ/(KG)(K)	10.2980	10.2980
M, (1/n)	22.912	22.924
MW, MOL WT	21.286	21.296
Cp, KJ/(KG)(K)	2.3375	0.0000
GAMMAs	1.1885	0.0000
SON VEL,M/SEC	1047.1	0.0

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MACH NUMBER 0.000 0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6670
Ivac, M/SEC	1842.6
Isp, M/SEC	990.6

MOLE FRACTIONS

ALOH	0.00004	AL(OH)3	0.00002	*CO	0.21240
*CO2	0.00801	*H	0.00200	HCN	0.00005
HCO	0.00001	HNC	0.00001	*H2	0.42478
H2O	0.10109	NH3	0.00011	*N2	0.18083
*OH	0.00011	AL2O3(L)	0.07100		

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH4	CH3OH	CH3OOH	*CN
CNN	COOH	*C2	C2H	C2H2,acetylene
C2H2,vinylidene	CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl
CH3CN	CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal
CH3COOH	OHCH2COOH	C2H5	C2H6	CH3N2CH3
C2H5OH	CH3OCH3	CH3O2CH3	CCN	CNC
OCCN	C2N2	C2O	*C3	C3H3,1-propynl
C3H3,2-propynl	C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl
C3H6,propylene	C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal
C3H7,n-propyl	C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol
CNCOCN	C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-
C4H6,butadiene	C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene
C4H8,cis2-buten	C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2
C4H9,n-butyl	C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane
C4H10,isobutane	C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-
C5H10,1-pentene	C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane
C5H12,i-pentane	CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy
C6H6	C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-
C6H13,n-hexyl	C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx
C7H14,1-heptene	C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene
C8H10,ethylbenz	C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane
C9H19,n-nonyl	C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl
HALO	HALO2	HCCN	HCCO	HNCO
HNO	HNO2	HNO3	HO2	HCHO,formaldehy
HCOOH	H2O2	(HCOOH)2	*N	NCO
*NH	NH2	NH2OH	*NO	NO2
NO3	NCN	N2H2	NH2NO2	N2H4
N2O	N2O3	N2O4	N2O5	N3
N3H	*O	*O2	O3	AL(cr)
AL(L)	ALH3(a)	ALN(cr)	ALN(L)	AL(OH)3(a)

AL4C3(cr) C(gr) H2O(cr) H2O(L)

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

POINT	ITN	T	N	H	O	AL
		C				
1	3	2543.680	-12.315	-8.133	-21.178	-19.680
		-9.287				
Pinf/Pt = 1.764880						
2	3	2322.998	-12.437	-8.262	-22.150	-21.120
		-9.058				
ADD AL2O3(a)						
2	2	2327.000	-12.440	-8.265	-22.130	-21.091
		-9.074				
Pinf/Pt = 1.613090						
2	2	2327.000	-12.395	-8.220	-22.130	-21.091
		-8.984				
REMOVE AL2O3(a)						
2	2	2356.919	-12.418	-8.241	-21.987	-20.878
		-9.099				
WARNING!! DISCONTINUITY AT THE THROAT (ROCKET)						
Pinf/Pt = 1.746357						
2	2	2326.958	-12.435	-8.260	-22.130	-21.091
		-9.063				
ADD AL2O3(a)						
2	1	2327.000	-12.435	-8.260	-22.130	-21.091
		-9.063				
3	5	1490.570	-13.032	-8.888	-28.738	-31.264
		-6.879				
PHASE CHANGE, REPLACE AL2O3(L) WITH AL2O3(a)						
3	2	1584.520	-13.127	-8.980	-27.618	-30.752
		-7.654				
3	4	1283.948	-13.392	-9.253	-31.825	-38.155
		-5.971				
3	2	1291.653	-13.384	-9.245	-31.691	-37.920
		-6.027				
4	3	1176.346	-13.508	-9.370	-33.893	-41.774
		-5.104				
4	0	1176.348	-13.508	-9.370	-33.893	-41.774
		-5.104				
4	2	1170.241	-13.515	-9.377	-34.022	-42.000
		-5.049				
5	3	1087.027	-13.619	-9.481	-35.941	-45.343
		-4.234				
5	2	1093.089	-13.611	-9.473	-35.791	-45.082
		-4.298				
6	3	1044.353	-13.680	-9.542	-37.050	-47.273
		-3.765				
6	2	1038.998	-13.688	-9.550	-37.196	-47.527
		-3.703				

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 1740.5 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT	EXIT	EXIT	EXIT	EXIT
Pinf/P	1.0000	1.7464	77.894	134.07	195.99	262.18
P, BAR	120.00	68.714	1.5406	0.89507	0.61228	0.45771
T, K	2543.68	2327.00	1291.65	1170.24	1093.09	1039.00
RHO, KG/CU M	1.3003 1	8.1426 0	3.2902-1	2.1104-1	1.5463-1	1.2172-1
H, KJ/KG	-3237.50	-3729.75	-6252.25	-6494.32	-6649.95	-6762.22
U, KJ/KG	-4160.37	-4573.64	-6720.47	-6918.44	-7045.92	-7138.27
G, KJ/KG	-29166.7	-27450.2	-19418.8	-18423.3	-17792.4	-17353.3
S, KJ/(KG)(K)	10.1936	10.1936	10.1936	10.1936	10.1936	10.1936
M, (1/n)	22.917	22.927	22.937	22.941	22.952	22.973
MW, MOL WT	21.290	21.298	21.306	21.311	21.320	21.338
(dLV/dLP)t	-1.00080	-1.00044	-1.00022	-1.00064	-1.00158	-1.00329
(dLV/dLT)p	1.0118	0.0000	1.0022	1.0075	1.0202	1.0447
Cp, KJ/(KG)(K)	2.3242	0.0000	1.9969	2.0161	2.0828	2.2163
GAMMAs	1.1891	0.0000	1.2227	1.2223	1.2187	1.2120
SON VEL,M/SEC	1047.5	0.0	756.6	720.0	694.7	675.1
MACH NUMBER	0.000	0.000	3.245	3.545	3.761	3.933

PERFORMANCE PARAMETERS

Ae/At	1.0000	10.000	15.000	20.000	25.000
CSTAR, M/SEC	1485.3	1485.3	1485.3	1485.3	1485.3
CF	0.6680	1.6532	1.7183	1.7589	1.7876
Ivac, M/SEC	1842.7	2646.2	2718.4	2764.0	2796.7
Isp, M/SEC	992.2	2455.5	2552.2	2612.4	2655.1

MOLE FRACTIONS

ALOH	0.00004	0.00001	0.00000	0.00000	0.00000	0.00000
AL(OH)3	0.00002	0.00001	0.00000	0.00000	0.00000	0.00000
CH4	0.00001	0.00001	0.00004	0.00014	0.00036	0.00077
*CO	0.21232	0.21168	0.19801	0.19261	0.18786	0.18356
*CO2	0.00800	0.00877	0.02253	0.02788	0.03251	0.03657
*H	0.00174	0.00085	0.00000	0.00000	0.00000	0.00000
HCN	0.00006	0.00004	0.00000	0.00000	0.00000	0.00000
HCO	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000

HNC	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
*H2	0.42469	0.42618	0.44058	0.44572	0.44987	0.45305
H2O	0.10109	0.10041	0.08674	0.08151	0.07715	0.07358
NH3	0.00015	0.00011	0.00003	0.00003	0.00003	0.00003
*N2	0.18075	0.18086	0.18099	0.18103	0.18111	0.18126
*OH	0.00010	0.00004	0.00000	0.00000	0.00000	0.00000
AL2O3(a)	0.00000	0.00002	0.07107	0.07108	0.07112	0.07117
AL2O3(L)	0.07098	0.07102	0.00000	0.00000	0.00000	0.00000

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH
OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl
C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane
C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6
C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCCN	HCCO	HNCO	HNO
HNO2	HNO3	HO2	HCHO,formaldehy	HCOOH
H2O2	(HCOOH)2	*N	NCO	*NH
NH2	NH2OH	*NO	NO2	NO3
NCN	N2H2	NH2NO2	N2H4	N2O
N2O3	N2O4	N2O5	N3	N3H
*O	*O2	O3	AL(cr)	AL(L)
ALH3(a)	ALN(cr)	ALN(L)	AL(OH)3(a)	AL4C3(cr)
C(gr)	H2O(cr)	H2O(L)		

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

THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 1740.5 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7464
P, BAR	120.00	68.714
T, K	2543.68	2327.00
RHO, KG/CU M	1.3003 1	8.1426 0
H, KJ/KG	-3237.50	-3729.75
U, KJ/KG	-4160.37	-4573.64
G, KJ/KG	-29166.7	-27450.2
S, KJ/(KG)(K)	10.1936	10.1936
M, (1/n)	22.917	22.927
MW, MOL WT	21.290	21.298
(dLV/dLP)t	-1.00080	-1.00044
(dLV/dLT)p	1.0118	0.0000
Cp, KJ/(KG)(K)	2.3242	0.0000
GAMMAs	1.1891	0.0000
SON VEL,M/SEC	1047.5	0.0
MACH NUMBER	0.000	0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6680
Ivac, M/SEC	1842.7
Isp, M/SEC	992.2

MOLE FRACTIONS

ALOH	0.00004	0.00001
AL(OH)3	0.00002	0.00001
CH4	0.00001	0.00001
*CO	0.21232	0.21168
*CO2	0.00800	0.00877
*H	0.00174	0.00085
HCN	0.00006	0.00004
HCO	0.00001	0.00000
HNC	0.00001	0.00000
*H2	0.42469	0.42618
H2O	0.10109	0.10041
NH3	0.00015	0.00011
*N2	0.18075	0.18086

*OH	0.00010	0.00004
AL2O3(a)	0.00000	0.00002
AL2O3(L)	0.07098	0.07102

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH
OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl
C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane
C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6
C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCCN	HCCO	HNCO	HNO
HNO2	HNO3	HO2	HCHO,formaldehy	HCOOH
H2O2	(HCOOH)2	*N	NCO	*NH
NH2	NH2OH	*NO	NO2	NO3
NCN	N2H2	NH2NO2	N2H4	N2O
N2O3	N2O4	N2O5	N3	N3H
*O	*O2	O3	AL(cr)	AL(L)
ALH3(a)	ALN(cr)	ALN(L)	AL(OH)3(a)	AL4C3(cr)
C(gr)	H2O(cr)	H2O(L)		

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

THEORETICAL ROCKET PERFORMANCE ASSUMING FROZEN COMPOSITION
AFTER POINT 2

Pin = 1740.5 PSIA
CASE =

FileEditor:xEx8.out

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7464
P, BAR	120.00	68.714
T, K	2543.68	2327.00
RHO, KG/CU M	1.3003 1	8.1426 0
H, KJ/KG	-3237.50	-3729.75
U, KJ/KG	-4160.37	-4573.64
G, KJ/KG	-29166.7	-27450.2
S, KJ/(KG)(K)	10.1936	10.1936
M, (1/n)	22.917	22.927
MW, MOL WT	21.290	21.298
Cp, KJ/(KG)(K)	2.3242	0.0000
GAMMAs	1.1891	0.0000
SON VEL,M/SEC	1047.5	0.0
MACH NUMBER	0.000	0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6680
Ivac, M/SEC	1842.7
Isp, M/SEC	992.2

MOLE FRACTIONS

ALOH	0.00004	AL(OH)3	0.00002	CH4	0.00001
*CO	0.21240	*CO2	0.00801	*H	0.00174
HCN	0.00006	HCO	0.00001	HNC	0.00001
*H2	0.42485	H2O	0.10113	NH3	0.00015
*N2	0.18082	*OH	0.00010	AL2O3(L)	0.07101

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH
OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl

C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane
C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6
C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCCN	HCCO	HNCO	HNO
HNO2	HNO3	HO2	HCHO,formaldehy	HCOOH
H2O2	(HCOOH)2	*N	NCO	*NH
NH2	NH2OH	*NO	NO2	NO3
NCN	N2H2	NH2NO2	N2H4	N2O
N2O3	N2O4	N2O5	N3	N3H
*O	*O2	O3	AL(cr)	AL(L)
ALH3(a)	ALN(cr)	ALN(L)	AL(OH)3(a)	AL4C3(cr)
C(gr)	H2O(cr)	H2O(L)		

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

POINT	ITN	T	N	H	O	AL
		C				
1	3	2544.681	-12.204	-8.022	-21.174	-19.674
		-9.068				
Pinf/Pt = 1.765104						
2	3	2323.409	-12.326	-8.151	-22.147	-21.117
		-8.837				
ADD AL2O3(a)						
2	2	2327.000	-12.329	-8.153	-22.130	-21.091
		-8.851				
Pinf/Pt = 1.612860						
2	2	2327.000	-12.284	-8.108	-22.130	-21.091
		-8.761				
REMOVE AL2O3(a)						
2	2	2357.497	-12.307	-8.130	-21.984	-20.874
		-8.878				
WARNING!! DISCONTINUITY AT THE THROAT (ROCKET)						
Pinf/Pt = 1.748519						
2	2	2326.959	-12.324	-8.149	-22.130	-21.092
		-8.841				
ADD AL2O3(a)						
2	1	2327.000	-12.324	-8.149	-22.130	-21.091
		-8.841				
3	5	1490.611	-12.921	-8.777	-28.738	-31.263

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                -6.656
 PHASE CHANGE, REPLACE  AL2O3(L)       WITH  AL2O3(a)
   3    2    1584.517     -13.016      -8.869     -27.618     -30.752
                -7.431
   3    4    1284.051     -13.280      -9.142     -31.822     -38.152
                -5.750
   3    2    1291.759     -13.272      -9.134     -31.688     -37.917
                -5.805
   4    3    1176.743     -13.396      -9.259     -33.883     -41.761
                -4.888
   4    0    1176.744     -13.396      -9.259     -33.883     -41.761
                -4.888
   4    2    1170.672     -13.404      -9.266     -34.012     -41.986
                -4.833
   5    3    1088.171     -13.508      -9.371     -35.910     -45.298
                -4.033
   5    2    1094.186     -13.500      -9.363     -35.761     -45.039
                -4.095
   6    3    1046.369     -13.570      -9.433     -36.990     -47.186
                -3.582
   6    3    1041.132     -13.578      -9.441     -37.132     -47.434
                -3.523
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THEORETICAL ROCKET PERFORMANCE ASSUMING EQUILIBRIUM

COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 2175.6 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT	EXIT	EXIT	EXIT	EXIT
Pinf/P	1.0000	1.7485	77.893	134.04	195.87	261.84
P, BAR	150.00	85.787	1.9257	1.1190	0.76581	0.57288
T, K	2544.68	2327.00	1291.76	1170.67	1094.19	1041.13
RHO, KG/CU M	1.6250 1	1.0167 1	4.1127-1	2.6380-1	1.9329-1	1.5215-1
H, KJ/KG	-3237.50	-3730.87	-6252.33	-6494.34	-6649.85	-6761.96
U, KJ/KG	-4160.57	-4574.67	-6720.56	-6918.55	-7046.06	-7138.48
G, KJ/KG	-28970.9	-27262.9	-19315.4	-18332.9	-17714.9	-17290.5
S, KJ/(KG)(K)	10.1126	10.1126	10.1126	10.1126	10.1126	10.1126
M, (1/n)	22.921	22.929	22.938	22.945	22.962	22.991
MW, MOL WT	21.294	21.300	21.308	21.314	21.328	21.353
(dLV/dLP)t	-1.00083	-1.00048	-1.00034	-1.00098	-1.00238	-1.00477
(dLV/dLT)p	1.0108	0.0000	1.0034	1.0116	1.0304	1.0646
Cp, KJ/(KG)(K)	2.3152	0.0000	2.0015	2.0336	2.1302	2.3135

GAMMAs	1.1894	0.0000	1.2225	1.2215	1.2167	1.2083
SON VEL,M/SEC	1047.8	0.0	756.6	719.8	694.3	674.5
MACH NUMBER	0.000	0.000	3.246	3.545	3.763	3.936

PERFORMANCE PARAMETERS

Ae/At	1.0000	10.000	15.000	20.000	25.000
CSTAR, M/SEC	1485.3	1485.3	1485.3	1485.3	1485.3
CF	0.6688	1.6532	1.7183	1.7589	1.7875
Ivac, M/SEC	1842.8	2646.2	2718.4	2764.1	2796.8
Isp, M/SEC	993.3	2455.5	2552.2	2612.4	2655.0

MOLE FRACTIONS

ALOH	0.00003	0.00001	0.00000	0.00000	0.00000	0.00000
AL(OH)3	0.00003	0.00001	0.00000	0.00000	0.00000	0.00000
CH4	0.00001	0.00001	0.00007	0.00022	0.00055	0.00114
*CO	0.21233	0.21168	0.19800	0.19256	0.18776	0.18339
*CO2	0.00800	0.00877	0.02253	0.02788	0.03250	0.03654
*H	0.00157	0.00076	0.00000	0.00000	0.00000	0.00000
HCN	0.00008	0.00004	0.00000	0.00000	0.00000	0.00000
HCO	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
HNC	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
HNCO	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
*H2	0.42474	0.42620	0.44052	0.44555	0.44945	0.45223
HCHO,formaldehy	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000
H2O	0.10114	0.10043	0.08677	0.08160	0.07739	0.07406
NH3	0.00019	0.00014	0.00003	0.00003	0.00003	0.00004
*N2	0.18076	0.18086	0.18100	0.18105	0.18117	0.18139
*OH	0.00009	0.00003	0.00000	0.00000	0.00000	0.00000
AL2O3(a)	0.00000	0.00002	0.07107	0.07110	0.07114	0.07123
AL2O3(L)	0.07100	0.07102	0.00000	0.00000	0.00000	0.00000

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH
OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl
C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane

C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6
C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCCN	HCCO	HNO	HNO2
HNO3	HO2	HCOOH	H2O2	(HCOOH)2
*N	NCO	*NH	NH2	NH2OH
*NO	NO2	NO3	NCN	N2H2
NH2NO2	N2H4	N2O	N2O3	N2O4
N2O5	N3	N3H	*O	*O2
O3	AL(cr)	AL(L)	ALH3(a)	ALN(cr)
ALN(L)	AL(OH)3(a)	AL4C3(cr)	C(gr)	H2O(cr)
H2O(L)				

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

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COMPOSITION DURING EXPANSION FROM INFINITE AREA COMBUSTOR

Pin = 2175.6 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7485
P, BAR	150.00	85.787
T, K	2544.68	2327.00
RHO, KG/CU M	1.6250 1	1.0167 1
H, KJ/KG	-3237.50	-3730.87
U, KJ/KG	-4160.57	-4574.67
G, KJ/KG	-28970.9	-27262.9
S, KJ/(KG)(K)	10.1126	10.1126
M, (1/n)	22.921	22.929
MW, MOL WT	21.294	21.300
(dLV/dLP)t	-1.00083	-1.00048
(dLV/dLT)p	1.0108	0.0000
Cp, KJ/(KG)(K)	2.3152	0.0000
GAMMAs	1.1894	0.0000
SON VEL,M/SEC	1047.8	0.0
MACH NUMBER	0.000	0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6688
Ivac, M/SEC	1842.8
Isp, M/SEC	993.3

MOLE FRACTIONS

ALOH	0.00003	0.00001
AL(OH)3	0.00003	0.00001
CH4	0.00001	0.00001
*CO	0.21233	0.21168
*CO2	0.00800	0.00877
*H	0.00157	0.00076
HCN	0.00008	0.00004
HCO	0.00001	0.00000
HNC	0.00001	0.00000
HNCO	0.00001	0.00000
*H2	0.42474	0.42620
HCHO,formaldehy	0.00001	0.00000
H2O	0.10114	0.10043
NH3	0.00019	0.00014
*N2	0.18076	0.18086
*OH	0.00009	0.00003
AL2O3(a)	0.00000	0.00002
AL2O3(L)	0.07100	0.07102

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH
OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl
C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane
C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6

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C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCCN	HCCO	HNO	HNO2
HNO3	HO2	HCOOH	H2O2	(HCOOH)2
*N	NCO	*NH	NH2	NH2OH
*NO	NO2	NO3	NCN	N2H2
NH2NO2	N2H4	N2O	N2O3	N2O4
N2O5	N3	N3H	*O	*O2
O3	AL(cr)	AL(L)	ALH3(a)	ALN(cr)
ALN(L)	AL(OH)3(a)	AL4C3(cr)	C(gr)	H2O(cr)
H2O(L)				

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

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AFTER POINT 2

Pin = 2175.6 PSIA
CASE =

	REACTANT	WT FRACTION (SEE NOTE)	ENERGY KJ/KG-MOL	TEMP K
OXIDANT	NH4NO3(IV)	1.0000000	-365342.184	300.000
FUEL	AL(cr)	0.5625000	44.802	300.000
NAME	HTPB	0.4375000	-51800.000	300.000

O/F= 2.12500 %FUEL= 32.000000 R,EQ.RATIO= 2.176413 PHI,EQ.RATIO= 4.529239

	CHAMBER	THROAT
Pinf/P	1.0000	1.7485
P, BAR	150.00	85.787
T, K	2544.68	2327.00
RHO, KG/CU M	1.6250 1	1.0167 1
H, KJ/KG	-3237.50	-3730.87
U, KJ/KG	-4160.57	-4574.67
G, KJ/KG	-28970.9	-27262.9
S, KJ/(KG)(K)	10.1126	10.1126
M, (1/n)	22.921	22.929
MW, MOL WT	21.294	21.300
Cp, KJ/(KG)(K)	2.3152	0.0000
GAMMAs	1.1894	0.0000
SON VEL,M/SEC	1047.8	0.0
MACH NUMBER	0.000	0.000

PERFORMANCE PARAMETERS

Ae/At	1.0000
CSTAR, M/SEC	1485.3
CF	0.6688

Ivac, M/SEC 1842.8
Isp, M/SEC 993.3

MOLE FRACTIONS

ALOH	0.00003	AL(OH)3	0.00003	CH4	0.00001
*CO	0.21240	*CO2	0.00800	*H	0.00157
HCN	0.00008	HCO	0.00001	HNC	0.00001
HNCO	0.00001	*H2	0.42488	HCHO,formaldehy	0.00001
H2O	0.10117	NH3	0.00019	*N2	0.18081
*OH	0.00009	AL2O3(L)	0.07102		

* THERMODYNAMIC PROPERTIES FITTED TO 20000.K

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

*AL	ALC	ALC2	ALH	ALH2
ALH3	ALN	*ALO	ALO2	AL(OH)2
AL2	AL2C2	AL2O	AL2O2	AL2O3
*C	*CH	CH2	CH3	CH2OH
CH3O	CH3OH	CH3OOH	*CN	CNN
COOH	*C2	C2H	C2H2,acetylene	C2H2,vinylidene
CH2CO,ketene	O(CH)2O	HO(CO)2OH	C2H3,vinyl	CH3CN
CH3CO,acetyl	C2H4	C2H4O,ethylen-o	CH3CHO,ethanal	CH3COOH
OHCH2COOH	C2H5	C2H6	CH3N2CH3	C2H5OH
CH3OCH3	CH3O2CH3	CCN	CNC	OCCN
C2N2	C2O	*C3	C3H3,1-propynl	C3H3,2-propynl
C3H4,allene	C3H4,propyne	C3H4,cyclo-	C3H5,allyl	C3H6,propylene
C3H6,cyclo-	C3H6O,propylox	C3H6O,acetone	C3H6O,propanal	C3H7,n-propyl
C3H7,i-propyl	C3H8	C3H8O,1propanol	C3H8O,2propanol	CNCOCN
C3O2	*C4	C4H2,butadiyne	C4H4,1,3-cyclo-	C4H6,butadiene
C4H6,1butyne	C4H6,2butyne	C4H6,cyclo-	C4H8,1-butene	C4H8,cis2-buten
C4H8,tr2-butene	C4H8,isobutene	C4H8,cyclo-	(CH3COOH)2	C4H9,n-butyl
C4H9,i-butyl	C4H9,s-butyl	C4H9,t-butyl	C4H10,n-butane	C4H10,isobutane
C4N2	*C5	C5H6,1,3cyclo-	C5H8,cyclo-	C5H10,1-pentene
C5H10,cyclo-	C5H11,pentyl	C5H11,t-pentyl	C5H12,n-pentane	C5H12,i-pentane
CH3C(CH3)2CH3	C6H2	C6H5,phenyl	C6H5O,phenoxy	C6H6
C6H5OH,phenol	C6H10,cyclo-	C6H12,1-hexene	C6H12,cyclo-	C6H13,n-hexyl
C6H14,n-hexane	C7H7,benzyl	C7H8	C7H8O,cresol-mx	C7H14,1-heptene
C7H15,n-heptyl	C7H16,n-heptane	C7H16,2-methylh	C8H8,styrene	C8H10,ethylbenz
C8H16,1-octene	C8H17,n-octyl	C8H18,n-octane	C8H18,isooctane	C9H19,n-nonyl
C10H8,naphthale	C10H21,n-decyl	C12H9,o-bipheny	C12H10,biphenyl	HALO
HALO2	HCCN	HCCO	HNO	HNO2
HNO3	HO2	HCOOH	H2O2	(HCOOH)2
*N	NCO	*NH	NH2	NH2OH
*NO	NO2	NO3	NCN	N2H2
NH2NO2	N2H4	N2O	N2O3	N2O4
N2O5	N3	N3H	*O	*O2
O3	AL(cr)	AL(L)	ALH3(a)	ALN(cr)
ALN(L)	AL(OH)3(a)	AL4C3(cr)	C(gr)	H2O(cr)
H2O(L)				

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