```
R134a                                   !short name
811-97-2                                !CAS number
1,1,1,2-tetrafluoroethane               !full name
CF3CH2F                                 !chemical formula {C2H2F4}
HFC-134a                                !synonym
102.032             !molecular weight [g/mol]
169.85              !triple point temperature [K]
247.076             !normal boiling point [K]
374.21              !critical temperature [K]
4059.28             !critical pressure [kPa]
5.017053            !critical density [mol/L]
0.32684             !acentric factor
2.058               !dipole moment [Debye]; Meyer & Morrison (1991) J. Chem.
Eng. Data 36:409-413.
IIR                 !default reference state
8.0                 !version number
3159                !UN Number
halocb              !family
```

```
! compiled by M. McLinden, NIST Physical and Chemical Properties Division,
Boulder, Colorado
! 10-10-95  MM, original version
! 03-14-96  MM, add transport correlations compiled by S.A. Klein
! 03-15-96  MM, modify transport format to conform to new structure
! 03-18-96  MM, add dipole moment
! 06-14-96  MM, add phi0 function of Tillner-Roth (transformed to CP1 form)
! 08-19-96  MM, add surface tension fit
! 10-03-96  MM, specify no rho-dependent ECS coeff (compatibility with new
model)
! 10-09-96  MM, A(4), A(5) coefficients missing from TC1 (thermal conductivity)
model
! 01-17-97  MM, add revised viscosity correlation of Laesecke + collision
integral
! 01-31-97  MM, change pointer for ECS reference viscosity from VS3 to VS1
!               modify ncoeff line for FEQ to accommodate critical region terms
! 02-07-97  MM, recast thermal cond model of Perkins into new TC1 form
! 02-20-97  MM, add default reference state
! 02-24-97  MM, put t.c. critical enhancement in TK1 form
! 02-26-97  MM, add version number and pointer to visc critical enhancement
(both future use)
! 03-05-97  MM, modify ECS-transport to new format
! 05-14-97  MM, change power of T in collision integral to integer
! 07-11-97  MM, revert to t.c. model of Perkins until Krauss model is debugged
! 08-21-97  MM, purge exponentials from values read by GUI (e.g. model limits)
! 10-24-97  MM, read in f_int term in Eucken correlation in ECS method for t.c.
!               change reference fluid EOS for ECS-transport from BWR to FEQ
! 10-27-99 EWL, change upper limit to 455 K
! 10-27-99 EWL, remove the 'd-3' in the triple point pressure
! 11-01-99 EWL, add Span 12 term short equation of state
! 01-25-00  MM, change Tlow for TCX from 170 to 169.85 K
! 01-25-00 EWL, update triple point pressure and density
! 09-26-01 MLH, added new Laesecke viscosity correlation as default
! 04-19-04 MLH, updated viscosity reference
! 11-19-04 MLH, added tPr
! 09-20-06 EWL, added Astina and Sato equation
! 10-03-06 EWL, changed maximum density from 17.05 to 20 in TCX and VIS to make
it work with RP1
! 12-02-06 MLH, revised LJ for ECS
! 03-05-07 MLH, added VS4
! 09-13-10 EWL, replace ancillary equations
! 10-15-10 MLH, revised limits on TK3 block to be consistent with TC1
```

```
#EOS               !equation of state specification
FEQ  Helmholtz equation of state for R-134a of Tillner-Roth & Baehr (1994).
?LITERATURE REFERENCE \
?Tillner-Roth, R. and Baehr, H.D.,
? "An international standard formulation of the thermodynamic properties
? of 1,1,1,2-tetrafluoroethane (HFC-134a) for temperatures from 170 K
? to 455 K at pressures up to 70 MPa,"
? J. Phys. Chem. Ref. Data, 23:657-729, 1994.\
?\
?Typical uncertainties are 0.05% for density, 0.02% for vapor
?pressure, 0.5-1% for heat capacity, 0.05% for vapor speed of sound,
?and 1% for liquid speed of sound, except in the critical region.
?\
!end of info section
169.85             !lower temperature limit [K]
455.0              !upper temperature limit [K]
70000.0            !upper pressure limit [kPa]
15.60              !maximum density [mol/L]
CPP                                  !pointer to Cp0 model
102.032                              !molecular weight [g/mol]
169.85                               !triple point temperature [K]
0.3896                               !pressure at triple point [kPa]
15.5942                              !density at triple point [mol/L]
247.076                              !normal boiling point temperature [K]
0.32684                              !acentric factor
374.21       4059.28      5.017053     !Tc [K], pc [kPa], rhoc [mol/L]
374.18                    4.978830171  !reducing parameters [K, mol/L]
8.314471                             !gas constant [J/mol-K]
      21  4      0  0       0  0       !# terms, # coeff/term for:  "normal"
terms, critical, spare
  0.5586817000d-01  -0.50   2.00   0   !a(i),t(i),d(i),l(i)
  0.4982230000d+00   0.00   1.00   0
  0.2458698000d-01   0.00   3.00   0
  0.8570145000d-03   0.00   6.00   0
  0.4788584000d-03   1.50   6.00   0
 -0.1800808000d+01   1.50   1.00   0
  0.2671641000d+00   2.00   1.00   0
 -0.4781652000d-01   2.00   2.00   0
  0.1423987000d-01   1.00   5.00   1
  0.3324062000d+00   3.00   2.00   1
 -0.7485907000d-02   5.00   2.00   1
  0.1017263000d-03   1.00   4.00   2
 -0.5184567000d+00   5.00   1.00   2
 -0.8692288000d-01   5.00   4.00   2
  0.2057144000d+00   6.00   1.00   2
 -0.5000457000d-02  10.00   2.00   2
  0.4603262000d-03  10.00   4.00   2
 -0.3497836000d-02  10.00   1.00   3
  0.6995038000d-02  18.00   5.00   3
 -0.1452184000d-01  22.00   3.00   3
 -0.1285458000d-03  50.00  10.00   4
```

```
#AUX               !auxiliary model specification
CPP  ideal gas heat capacity function
?LITERATURE REFERENCE \
?Tillner-Roth, R. and Baehr, H.D.,
? "An international standard formulation of the thermodynamic properties
? of 1,1,1,2-tetrafluoroethane (HFC-134a) for temperatures from 170 K
? to 455 K at pressures up to 70 MPa,"
? J. Phys. Chem. Ref. Data, 23:657-729, 1994.\
?\
?Note:  Tillner-Roth et al. give a Helmholtz form for the ideal gas term; it
?has been converted to a Cp0 form by the transform: \
?\
?   Cp0/R = (1 + a3) - (3/4)*a4*Tr**(1/2) - (21/16)*a5*Tr**(3/4) \
?   where the ai are the original coefficients given by T-R and Tr = T/Tc \
?\
!end of info section
169.85             !lower temperature limit [K]
455.0              !upper temperature limit [K]
0.0                !upper pressure limit [kPa]
0.0                !maximum density [mol/L]
374.18       8.314471                  !reducing parameters for T, Cp0
  3  0    0  0    0  0  0              !Nterms:  polynomial, exponential, cosh,
sinh
-0.629789d0        0.00                !c(i), power of T
 7.292937d0        0.50
 5.154411d0        0.75
```

```
@EOS               !equation of state specification
FES  short Helmholtz equation of state for R-134a of Span and Wagner (2003).
?LITERATURE REFERENCE \
?Span, R. and Wagner, W.
? "Equations of State for Technical Applications. III. Results for Polar
Fluids,"
? Int. J. Thermophys., 24(1):111-162, 2003.
?\
?The uncertainties of the equation of state are approximately 0.2% (to
?0.5% at high pressures) in density, 1% (in the vapor phase) to 2% in
?heat capacity, 1% (in the vapor phase) to 2% in the speed of sound, and
?0.2% in vapor pressure, except in the critical region.
?\
!end of info section
169.85             !lower temperature limit [K]
600.0              !upper temperature limit [K]
100000.0           !upper pressure limit [kPa]
15.6               !maximum density [mol/L]
CPP                                  !pointer to Cp0 model
102.032                              !molecular weight [g/mol]
169.85                               !triple point temperature [K]
0.38818                              !pressure at triple point [kPa]
15.588                               !density at triple point [mol/L]
247.06                               !normal boiling point temperature [K]
0.327                                !acentric factor
374.18       4056.3       4.9788302  !Tc [K], pc [kPa], rhoc [mol/L]
374.18                    4.9788302  !reducing parameters [K, mol/L]
8.31451                              !gas constant [J/mol-K]
      12  4      0  0       0  0     !# terms, # coeff/term for:  "normal"
terms, critical, spare
 0.106631890000E+01  0.25    1.0     0 !a(i),t(i),d(i),l(i)
-0.244959700000E+01  1.25    1.0     0
 0.446457180000E-01  1.5     1.0     0
 0.756568840000E-01  0.25    3.0     0
 0.206520890000E-03  0.875   7.0     0
 0.420069120000E+00  2.375   1.0     1
 0.767391110000E+00  2.0     2.0     1
 0.178974270000E-02  2.125   5.0     1
-0.362197460000E+00  3.5     1.0     2
-0.678093700000E-01  6.5     1.0     2
-0.106164190000E+00  4.75    4.0     2
-0.181857910000E-01 12.5     2.0     3
```

```
@EOS               !equation of state specification
BWR  MBWR equation of state for R-134a of Huber and McLinden (1992).
?LITERATURE REFERENCES \
?Huber, M.L. and McLinden, M.O.,
? "Thermodynamic properties of R134a (1,1,1,2-tetrafluoroethane),"
? International Refrigeration Conference,
? West Lafayette, IN, July 14-17, 453-462, 1992.\
?\
?also published in: \
?\
?Huber, M.L. and Ely, J.F.,
? "A predictive extended corresponding states model for pure and mixed
? refrigerants including an equation of state for R134a,"
? Int. J. Refrigeration, 17:18-31, 1994.\
?\
!end of info section
169.85             !lower temperature limit [K]
600.0              !upper temperature limit [K]
70000.0            !upper pressure limit [kPa]
15.60              !maximum density [mol/L]
CP1                                  !pointer to Cp0 model
102.032                              !molecular weight [g/mol]
169.85                               !triple point temperature [K]
0.3922                               !pressure at triple point [kPa]
15.60                                !density at triple point [mol/L]
247.082                              !normal boiling point temperature [K]
0.32705                              !acentric factor
374.179      4056.        5.0308     !Tc [K], pc [kPa], rhoc [mol/L]
374.179                   5.0308     !reducing parameters [K, mol/L]
5.0308                               !gamma
0.08314471                           !gas constant [L-bar/mol-K]
      32       1                     !Nterm, Ncoeff per term
 0.965209362217d-01   -0.401824768889d+01    0.395239532858d+02
 0.134532868960d+04   -0.139439741347d+07   -0.309281355175d-02
 0.292381512283d+01   -0.165146613555d+04    0.150706003118d+07
 0.534973948313d-04    0.543933317622d+00   -0.211326049762d+03
-0.268191203847d-01   -0.541067125950d+00   -0.851731779398d+03
 0.205188253646d+00   -0.733050188093d-02    0.380655963862d+01
-0.105832087589d+00   -0.679243084424d+06   -0.126998378601d+09
-0.426234431829d+05    0.101973338234d+10   -0.186699526782d+03
-0.933426323419d+05   -0.571735208963d+01   -0.176762738787d+06
-0.397282752308d-01    0.143016844796d+02    0.803085294260d-04
-0.171959073552d+00    0.226238385661d+01
```

```
#AUX               !auxiliary model specification
CP1  ideal gas heat capacity function of McLinden et al. (1989).
?LITERATURE REFERENCES \
?McLinden, M.O., et al.,
? "Measurement and formulation of the thermodynamic properties of refrigerants
? 134a (1,1,1,2-tetrafluoroethane) and 123 (1,1-dichloro-2,2,2-
trifluoroethane),"
? ASHRAE Trans. 95(2):263-283, 1989.\
?\
?also published in (and used in fits of): \
?\
?Huber, M.L. and McLinden, M.O.,
? "Thermodynamic properties of R134a (1,1,1,2-tetrafluoroethane),"
? International Refrigeration Conference,
? West Lafayette, IN, July 14-17, 453-462, 1992.\
?
?Huber, M.L. and Ely, J.F.,
? "A predictive extended corresponding states model for pure and mixed
? refrigerants including an equation of state for R134a,"
? Int. J. Refrigeration, 17:18-31, 1994.\
?\
!end of info section
150.0              !lower temperature limit [K]
500.0              !upper temperature limit [K]
0.0                !upper pressure limit [kPa]
0.0                !maximum density [mol/L]
1.0          1.0                       !reducing parameters for T, Cp0
  3  0    0  0    0  0  0               !Nterms:  polynomial, exponential, cosh,
sinh
19.4006d0          0.00                !c(i), power of T
 0.258531d0        1.00
-1.29665d-4        2.00
```

```
@EOS               !equation of state specification
FE2  Helmholtz equation of state for R-134a of Astina and Sato (2004)
?LITERATURE REFERENCE \
?Astina, I.M. and Sato, H.,
? "A Fundamental Equation of State for 1,1,1,2-Tetrafluoroethane with an
? Intermolecular Potential Energy Background and Reliable Ideal-Gas
Properties,"
? Fluid Phase Equilib., 221:103-111, 2004.
?\
!end of info section
169.85             !lower temperature limit [K]
460.0              !upper temperature limit [K]
70000.0            !upper pressure limit [kPa]
15.58              !maximum density [mol/L]
PH2                                  !pointer to Cp0 model
102.031                              !molecular weight [g/mol]
169.85                               !triple point temperature [K]
0.327                                !pressure at triple point [kPa]
15.58                                !density at triple point [mol/L]
247.087                              !normal boiling point temperature [K]
0.33                                 !acentric factor
374.083      4048.0     4.988679911  !Tc [K], pc [kPa], rhoc [mol/L]
374.083                 4.988679911  !reducing parameters [K, mol/L]
8.314472                             !gas constant [J/mol-K]
      18  4      0  0       0  0     !# terms, # coeff/term for:  "normal"
terms, critical, spare
 1.832124209         0.5    1.00   0   !a(i),t(i),d(i),l(i)
-2.940698861         1.125  1.00   0
 5.156071823d-1      3.25   1.00   0
 2.756965911d-1      0.5    2.00   0
 1.225264939         1.875  2.00   0
-6.486749497d-1      2.75   2.00   0
-9.286738053d-1      1.625  3.00   0
 3.920381291d-1      2.125  3.00   0
 1.056692108d-1      1.125  4.00   0
-7.586523371d-1      3.75   1.00   1
-1.198140136         1.5    2.00   1
-2.878260390d-1      0.75   3.00   1
-9.723032379d-2      9.     2.00   2
 5.307113358d-2      8.5    3.00   2
-4.681610582d-2      5.5    4.00   2
-9.604697902d-3     32.     4.00   3
 6.668035048d-3     23.     5.00   3
 2.361266290d-3     31.     6.00   3
```

```
#AUX               !auxiliary model specification
PH2  Helmholtz form for the ideal-gas state
?LITERATURE REFERENCE \
?Astina, I.M. and Sato, H.,
!end of info section
169.85             !lower temperature limit [K]
460.0              !upper temperature limit [K]
0.0                !upper pressure limit [kPa]
0.0                !maximum density [mol/L]
1 3  3  0 0  0 0 0 !Nterms:  ai*log(tau**ti); ai*tau**ti; ai*log(1-exp(bi*tau))
-1.              1.0              !ai, ti for [ai*log(tau**ti)] terms
10.78497786      0.0              !aj, ti for [ai*tau**ti] terms
8.612977410      1.0
-24.37548384    -0.25
 7.451784998    -4.103830338
-4.239239505    -2.561528683
 6.445739825    -2.084607363
```

```
@AUX               !auxiliary model specification
PH0  Helmholtz form for the ideal-gas state
?LITERATURE REFERENCE \
?Tillner-Roth, R. and Baehr, H.D.,
? "An international standard formulation of the thermodynamic properties
? of 1,1,1,2-tetrafluoroethane (HFC-134a) for temperatures from 170 K
? to 455 K at pressures up to 70 MPa,"
? J. Phys. Chem. Ref. Data, 23:657-729, 1994.\
?\
!end of info section
169.85             !lower temperature limit [K]
455.0              !upper temperature limit [K]
0.0                !upper pressure limit [kPa]
0.0                !maximum density [mol/L]
1 4  0  0 0  0 0 0 !Nterms:  ai*log(tau**ti); ai*tau**ti; ai*log(1-exp(bi*tau))
-1.629789d+0     1.00d0            !ai, ti for [ai*log(tau**ti)] terms
-1.019535d+0     0.00d0            !aj, ti for [ai*tau**ti] terms
 9.047135d+0     1.00d0
-9.723916d+0    -0.50d0
-3.927170d+0    -0.75d0
```

```
@EOS
PRT  translated Peng-Robinson equation
?LITERATURE REFERENCES \
?  volume translation of Peng Robinson EOS
?  translation computed so that sat. liquid density at Tr=0.7 matches FEQ
Helmholtz equation
?  of state for R134a of Tillner-Roth & Baehr (1994).
!end of info section
169.85              !lower temperature limit [K]
455.0               !upper temperature limit [K]
20000.0             !upper pressure limit [kPa]
17.05               !maximum density [mol/L]
CPP                 !pointer to Cp0 model
102.032             !molecular weight [g/mol]
0.32684             !acentric factor
374.21              !critical temperature [K]
4059.28             !critical pressure [kPa]
5.017053            !critical density [mol/L]
8.314472            !gas constant [J/mol-K]
1                   !Number of parameters
0.001032
```

```
#TCX                !thermal conductivity model specification
TC1  pure fluid thermal conductivity model of Perkins et al. (2000).
?LITERATURE REFERENCE \
?Perkins, R.A., Laesecke, A., Howley, J., Ramires, M.L.V., Gurova, A.N., and
? Cusco, L., "Experimental thermal conductivity values for the IUPAC
? round-robin sample of 1,1,1,2-tetrafluoroethane (R134a),"
? NISTIR, 2000.
?\
?The uncertainty in thermal conductivity is 5%.
?\
!end of info section
169.85              !lower temperature limit [K]
455.0               !upper temperature limit [K]
20000.0             !upper pressure limit [kPa]
20.0                !maximum density [mol/L]
2   0               !# terms for dilute gas function:  numerator, denominator
1.0     1.0         !reducing parameters for T, tcx
-1.05248d-2    0.00d0   !coeff, power in T
 8.00982d-5    1.00d0
4   0               !# terms for background gas function:  numerator,
denominator
1.0    5.049886     2.055d-03              !reducing par for T, rho (rho_c), tcx
 1.836526       0.0  1.0  0.0 !coeff, powers of T, rho, spare for future use
 5.126143d+0   0.00d0   2.00d0   0.00d0
-1.436883d+0   0.00d0   3.00d0   0.00d0
 6.261441d-1   0.00d0   4.00d0   0.00d0
TK3                 !pointer to critical enhancement auxiliary function
```

```
#AUX               !thermal conductivity critical enhancement model
TK3  simplified thermal conductivity critical enhancement of Olchowy & Sengers
?LITERATURE REFERENCE \
?Olchowy, G.A. and Sengers, J.V.,
? "A simplified representation for the thermal conductivity of fluids in the
? critical region,"
? Int. J. Thermophysics, 10:417-426, 1989.\
?\
?as applied to R134a by:\
?Perkins, R. (1997). National Institute of Standards and Technology, personal
? communication, fit of IUPAC round robin data.\
?\
!end of info section
169.85             !lower temperature limit [K]
455.0              !upper temperature limit [K]
20000.0            !upper pressure limit [kPa]
20.0               !maximum density [mol/L]
9  0  0  0         !# terms:  critical-terms, spare, spare, spare
1.0     1.0     1.0     !reducing par for T, rho, tcx
0.630              !gnu (universal exponent)
1.239              !gamma (universal exponent)
1.03               !R0 (universal amplitude)
0.063              !z (universal exponent--not used for t.c., only viscosity)
1.00               !c (constant in viscosity eqn = 1/[2 - (alpha +
gamma)/(2*nu)], but often set to 1)
1.94d-10           !xi0 (amplitude) [m]
0.0496             !gam0 (amplitude) [-]
5.285356d-10       !qd_inverse (modified effective cutoff parameter) [m]
561.411            !tref (reference temperature) [= 1.5 * 374.274 K]
```

```
#ETA                !viscosity model specification
VS1  pure fluid viscosity model of Huber, Laesecke and Perkins (2003).
?LITERATURE REFERENCE \
?Huber, M.L., Laesecke, A., and Perkins, R.A.,
? "Model for the Viscosity and Thermal Conductivity of Refrigerants,
? Including a New Correlation for the Viscosity of R134a",
? Ind. Eng. Chem. Res., 42:3163-3178, 2003.
?\
?The uncertainty in viscosity is 1.5% along the saturated liquid line, 3% in
?the liquid phase, 0.5% in the dilute gas, 3-5% in the vapor phase, and 5%
?in the supercritical region, rising to 8% at pressures above 40 MPa.
?Below 200 K, the uncertainty is 8%.
?\
!end of info section
169.85              !lower temperature limit [K]
500.0               !upper temperature limit [K]
100000.0            !upper pressure limit [kPa]
20.0                !maximum density [mol/L] (rho on melting line at 100 MPa)
1                   !number of terms associated with dilute-gas function
CI1                 !pointer to reduced effective collision cross-section model
0.468932            !Lennard-Jones coefficient sigma [nm]
299.363             !Lennard-Jones coefficient epsilon/kappa [K]
1.0    1.0          !reducing parameters for T, eta
0.215729d0  0.50d0 !=0.021357*SQRT(MW)  [Chapman-Enskog term]
9                   !number of terms for initial density dependence
299.363    0.0620984      !reducing parameters for T (=eps/k), etaB2 (=
0.6022137*sigma**3)
-0.19572881d+2   0.00d0   !coeff, power in T* = T/(eps/k)
 0.21973999d+3  -0.25d0
-0.10153226d+4  -0.50d0
 0.24710125d+4  -0.75d0
-0.33751717d+4  -1.00d0
 0.24916597d+4  -1.25d0
-0.78726086d+3  -1.50d0
 0.14085455d+2  -2.50d0
-0.34664158d+0  -5.50d0
 -3 7 1 2 0 0        !# resid terms:  close-packed density;  simple poly;
numerator of rational poly; denominator of rat. poly; numerator of exponential;
denominator of exponential
374.21    5.0170613    1.0d3       !reducing parameters for T, rho, eta
(Laesecke correlation in terms of mPa-s, convert to uPa-s)
 3.163695635587490      0.00       !alternative form for del10; numerator term
-0.8901733752064137d-1  1.00       !alternative form for del10; denominator
terms
 0.1000352946668359     2.00       !alternative form for del10; denominator
terms
-0.2069007192080741d-1  0.00  1.00  0.00  0  !beta1; powers of tau, del, del0;
power of del in exponential [0 indicated no exponential term present]
 0.3560295489828222d-3 -6.00  2.00  0.00  0  !beta2
 0.2111018162451597d-2 -2.00  2.00  0.00  0  !beta3
 0.1396014148308975d-1 -0.50  2.00  0.00  0  !beta4
-0.4564350196734897d-2  2.00  2.00  0.00  0  !beta5
-0.3515932745836890d-2  0.00  3.00  0.00  0  !beta6
-0.2147633195397038     0.00  0.00 -1.00  0  !beta7
 0.2147633195397038     0.00  0.00  0.00  0  !beta7 in non-simple poly term
 1.000000d+0            0.00  0.00  1.00  0  !del0 term in denominator
-1.000000d+0            0.00  1.00  0.00  0  !-del term in denominator
NUL                 !pointer to critical enhancement auxiliary function (none
used)
```

```
#AUX               !reduced effective collision cross-section model
specification
CI1  reduced effective collision cross-section model (empirical form in terms
of log(T*))
?LITERATURE REFERENCE \
?reduced effective collision cross-section of Wilhelm & Vogel as reported by:\
?Laesecke, A.,(laesecke@boulder.nist.gov); Unpublished correlation
R134aFitSelDV
? see
ftp://ftp.boulder.nist.gov/pub/fluids/NIST_Data/Viscosity/StandardReferenceCorr
elations/
?\
!end of info section
134.86             !lower temperature limit [K]
500.0              !upper temperature limit [K]
0.0                !(dummy) upper pressure limit
0.0                !(dummy) maximum density
3                  !number of terms
 0.355404d+0  0   !coeff, power of Tstar
-0.464337d+0  1
 0.257353d-1  2
```

```
@ETA                !viscosity model specification
VS4  pure fluid generalized friction theory viscosity model of Quinones-
Cisneros and Deiters (2006).
?LITERATURE REFERENCE \
? Quinones-Cisneros, S.E. and Deiters, U.K.
? "Generalization of the Friction Theory for Viscosity Modeling,"
? J. Phys. Chem. B, 110:12820-12834, 2006.
?
!end of info section
169.85              !lower temperature limit [K]
455.0               !upper temperature limit [K]
70000.0             !upper pressure limit [kPa]
15.60               !maximum density [mol/L]
4 0 0 0 0 0         !number of terms associated with dilute-gas function
NUL                 !pointer to reduced effective collision cross-section
model;not used
0.468932            !Lennard-Jones coefficient sigma [nm] (not used)
299.363             !Lennard-Jones coefficient epsilon/kappa [K] (not used)
374.21d0    1.0d0   !reducing parameters for T, eta
 0.0d0      0.5d0   !Chapman-Enskog term; not used here
 31.2515d0  0.00d0 !empirical terms for eta0
-89.6122d0  0.25d0
 73.0823d0  0.50d0
0                   !number of terms for initial density dependence; not yet
used.
 1.07271318464787d-04 -4.41655360682255d-05  0.00000000000000d+00
!a(0),a(1),a(2)
 1.66457266522365d-04 -4.80292908400793d-05  0.00000000000000d+00
!b(0),b(1),b(2)
 8.08333416284215d-05 -4.90359549823121d-05  0.00000000000000d+00
!c(0),c(1),c(2)
-2.12476175599662d-08  2.81647242085073d-09  0.00000000000000d+00
!A(0),A(1),A(2)
 1.35593527573090d-08  0.00000000000000d+00  3.17549774078234d-10
!B(0),B(1),B(2)
 0.00000000000000d+00  4.81768878752129d-07 -1.17148596093671d-07
!C(0),C(1),C(2)
 0.0d0                   0.0d0                   0.0d0
!D(0),D(1),D(2)
NUL                 !pointer to critical enhancement auxiliary function (none
used)
```

```
@TRN                !transport model specification
ECS  Extended Corresponding States model (R134a reference);     predictive
mode.
?LITERATURE REFERENCES \
?Klein, S.A., McLinden, M.O., and Laesecke, A.,
? "An improved extended corresponding states method for estimation of
? viscosity of pure refrigerants and mixtures,"
? Int. J. Refrigeration, 20:208-217, 1997.
?\
?McLinden, M.O., Klein, S.A., and Perkins, R.A.,
? "An extended corresponding states model for the thermal conductivity
? of refrigerants and refrigerant mixtures,"
? Int. J. Refrigeration, 23:43-63, 2000.
?
!end of info section
169.85              !lower temperature limit [K]
600.0               !upper temperature limit [K]
70000.0             !upper pressure limit [kPa]
15.60               !maximum density [mol/L]
FEQ r134a.fld
VS1                 !model for reference fluid viscosity
TC1                 !model for reference fluid thermal conductivity
1                   !Lennard-Jones flag (0 or 1) (0 => use estimates)
0.468932            !Lennard-Jones coefficient sigma [nm]
299.363             !Lennard-Jones coefficient epsilon/kappa [K]
1  0  0                        !number of terms in f_int term in Eucken
correlation, spare1, spare2
 1.32d-3        0.0  0.0  0.0 !coeff, power of T, spare 1, spare 2
1  0  0                        !number of terms in psi (visc shape factor):
poly,spare1,spare2
 1.0            0.0  0.0  0.0 !coeff, power of Tr, power of Dr, spare
1  0  0                        !number of terms in chi (t.c. shape factor):
poly,spare1,spare2
 1.0            0.0  0.0  0.0 !coeff, power of Tr, power of Dr, spare
NUL                          !pointer to critical enhancement auxiliary
function
```

```
#STN         !surface tension specification
ST1  surface tension model of Okada and Higashi (1994).
?LITERATURE REFERENCE \
?Okada, M. and Higashi, Y.,
? "Surface tension correlation of HFC-134a and HCFC-123,"
? CFCs, The Day After (Proceedings of the Joint Meeting of IIR
? Commissions B1, B2, E1, and E2), Padua, Italy, 541-548, 1994.\
?\
? as reported by:\
?Tillner-Roth, R. and Krauss, R.,
? "R134a--Extended Thermophysical Properties,"
? Paris, International Institute of Refrigeration, 1995.\
?
!end of info section
169.85              !lower temperature limit [K] (Higashi states 230 K, but
should extrapolate)
374.21              !upper temperature limit [K]
0.0                 !(dummy) upper pressure limit
0.0                 !(dummy) maximum density
1                           !number of terms in surface tension model
374.21                      !critical temperature used in fit (dummy)
 0.06016     1.260          !sigma0 and n
```

```
#PS          !vapor pressure equation
PS5  vapor pressure equation of Lemmon (2010).
?LITERATURE REFERENCE \
?Lemmon, E.W., 2010.
?\
!end of info section
169.85              !lower temperature limit [K]
374.21              !upper temperature limit [K]
0.0                 !(dummy) upper pressure limit
0.0                 !(dummy) maximum density
374.21  4059.28     !reducing parameters
4 0 0 0 0 0         !number of terms in equation
-0.77513D+01   1.0
 0.29263D+01   1.5
-0.26622D+01   1.9
-0.39711D+01   4.25
```

```
#DL         !saturated liquid density equation
DL1  saturated liquid density equation of Lemmon (2010).
?LITERATURE REFERENCE \
?Lemmon, E.W., 2010.
?\
!end of info section
169.85             !lower temperature limit [K]
374.21             !upper temperature limit [K]
0.0                !(dummy) upper pressure limit
0.0                !(dummy) maximum density
374.21  5.017053   !reducing parameters
5 0 0 0 0 0        !number of terms in equation
 0.12449D+02   0.5     !coefficients and exponents
-0.41023D+02   0.7
 0.73641D+02   0.9
-0.64635D+02   1.1
 0.22551D+02   1.3
```

```
#DV          !saturated vapor density equation
DV3  saturated vapor density equation of Lemmon (2010).
?LITERATURE REFERENCE \
?Lemmon, E.W., 2010.
?\
!end of info section
169.85              !lower temperature limit [K]
374.21              !upper temperature limit [K]
0.0                 !(dummy) upper pressure limit
0.0                 !(dummy) maximum density
374.21  5.017053    !reducing parameters
5 0 0 0 0 0         !number of terms in equation
-0.29174D+01   0.383     !coefficients and exponents
-0.72542D+01   1.21
-0.23306D+02   3.3
 0.59840D+01   5.6
-0.71821D+02   7.0
```

```
@END
c         1         2         3         4         5         6         7
8
c234567890123456789012345678901234567890123456789012345678901234567890123456789
0
```

```
@EOS                !equation of state specification
ECS  Thermodynamic Extended Corresponding States model w/ T-dependent shape
factors.
?LITERATURE REFERENCE \
?Huber, M.L. and Ely, J.F.,
? "A predictive extended corresponding states model for pure and mixed
? refrigerants including an equation of state for R134a,"
? Int. J. Refrigeration, 17:18-31, 1994.\
?\
?the ideal-gas contribution is computed with the polynomial Cp0 fit of:\
?McLinden, M.O., et al.,
? "Measurement and formulation of the thermodynamic properties of refrigerants
? 134a (1,1,1,2-tetrafluoroethane) and 123 (1,1-dichloro-2,2,2-
trifluoroethane),"
? ASHRAE Trans. 95(2):263-283, 1989.\
?\
?N.B. shape factors are unity as R134a is the reference fluid\
?
!end of info section
169.85              !lower temperature limit [K]
600.0               !upper temperature limit [K]
70000.0             !upper pressure limit [kPa]
15.60               !maximum density [mol/L]
CP1                 !pointer to Cp0 model
r134a.fld
BWR                 !pointer to reference fluid model
0.32668             !acentric factor for R134a used in shape factor correlation
0.259147            !critical compressibility for R134a used in correlation
0.32668             !acentric factor for fluid used in shape factor correlation
374.179             !critical temperature [K]
4056.0              !critical pressure [kPa]
5.0308              !critical density [mol/L]
2                         !number of temperature coefficients for 'f' shape
factor
 0.0          0.0         !alpha1 of Huber & Ely
 0.0          1.0         !alpha2 of Huber & Ely (log(Tr) term)
0                         !number of density coefficients for 'f' shape factor
2                         !number of temperature coefficients for 'h' shape
factor
 0.0          0.0         !beta1 of Huber & Ely
 0.0          1.0         !beta2 of Huber & Ely (log(Tr) term)
0                         !number of density coefficients for 'h' shape factor
```

Older formulation of Laesecke that has been replaced with the 1998 unpublished version given above:

```
@ETA                !viscosity model specification
VS1  pure fluid viscosity model of Laesecke (2000).
?LITERATURE REFERENCE \
?Laesecke, A.,
? "Data reassessment and full surface correlation of
? the viscosity of HFC-134a (1,1,1,2-tetrafluoroethane),"
?\
?The uncertainty in viscosity is 1.5% along the saturated liquid line, 3% in
?the liquid phase, 0.5% in the dilute gas, 3-5% in the vapor phase, and 5%
?in the supercritical region, rising to 8% at pressures above 40 MPa.
?Below 200 K, the uncertainty is 8%.
?\
!end of info section
169.85              !lower temperature limit [K]
500.0               !upper temperature limit [K]
100000.0            !upper pressure limit [kPa]
17.05               !maximum density [mol/L] (rho on melting line at 100 MPa)
1                   !number of terms associated with dilute-gas function
CI1                 !pointer to reduced effective collision cross-section model
0.50647             !Lennard-Jones coefficient sigma [nm]
288.82              !Lennard-Jones coefficient epsilon/kappa [K]
1.0    1.0          !reducing parameters for T, eta
0.215729d0  0.50d0 !=0.021357*SQRT(MW)  [Chapman-Enskog term]
13                  !number of terms for initial density dependence
288.82    0.07823693      !reducing parameters for T (=eps/k), etaB2 (=
0.6022137*sigma**3)
-0.17999496d+1   0.00d0   !coeff, power in T* = T/(eps/k)
 0.46692621d+2  -0.50d0
-0.53460794d+3  -1.00d0
 0.33604074d+4  -1.50d0
-0.13019164d+5  -2.00d0
 0.33414230d+5  -2.50d0
-0.58711743d+5  -3.00d0
 0.71426686d+5  -3.50d0
-0.59834012d+5  -4.00d0
 0.33652741d+5  -4.50d0
-0.12027350d+5  -5.00d0
 0.24348205d+4  -5.50d0
-0.20807957d+3  -6.00d0
2 3 2 2 0 0         !# resid terms:  close-packed density;  simple poly;
numerator of rational poly; denominator of rat. poly; numerator of exponential;
denominator of exponential
374.18    4.9788302    1.0d3       !reducing parameters for T, rho, eta
(Laesecke correlation in terms of mPa-s, convert to uPa-s)
 3.073830d+0     0.00              !c4; power of tau for del0
 0.482539055d+0  1.00              !c3*c4
-0.331249d-1  0.00  1.00  0.00  0  !c1; powers of tau, del, del0; power of del
in exponential [0 indicated no exponential term present]
-0.468509d-3  0.00  2.00  0.00  0  !c2
 0.306398d+0  0.00  0.00 -1.00  0  !-c5
-0.306398d+0  0.00  0.00  0.00  0  !c5
 0.215221d+0  0.00  1.00  0.00  0  !c6
 1.000000d+0  0.00  0.00  1.00  0  !del0 term in denominator
-1.000000d+0  0.00  1.00  0.00  0  !-del term in denominator
NUL                 !pointer to critical enhancement auxiliary function (none
used)
```

```
#AUX               !reduced effective collision cross-section model
specification
CI1  reduced effective collision cross-section model (empirical form in terms
of log(T*))
?LITERATURE REFERENCE \
?reduced effective collision cross-section of Wilhelm & Vogel as reported by:\
?Laesecke, A.,
? "Data reassessment and full surface correlation of
? the viscosity of HFC-134a (1,1,1,2-tetrafluoroethane),"
?\
!end of info section
134.86             !lower temperature limit [K]
500.0              !upper temperature limit [K]
0.0                !(dummy) upper pressure limit
0.0                !(dummy) maximum density
5                  !number of terms
 0.2218816d+0  0   !coeff, power of Tstar
-0.5079322d+0  1
 0.1285776d+0  2
-0.8328165d-2  3
-0.2713173d-2  4
```

```
#PS         !vapor pressure equation
PS6  vapor pressure equation of Tillner-Roth & Baehr (1994).
?LITERATURE REFERENCE \
?See EOS
?\
!end of info section
169.85             !lower temperature limit [K]
374.18             !upper temperature limit [K]
0.0                !(dummy) upper pressure limit
0.0                !(dummy) maximum density
374.18  4056.29    !reducing parameters
4 0 0 0 0 0                !number of terms in equation
 -7.686556           2.     !coefficients and exponents
  2.311791           3.
 -2.039554           4.
 -3.583758           8.
```

```
#DL         !saturated liquid density equation
DL2  saturated liquid density equation of Tillner-Roth & Baehr (1994).
?LITERATURE REFERENCE \
?See EOS
?\
!end of info section
169.85             !lower temperature limit [K]
374.18             !upper temperature limit [K]
0.0                !(dummy) upper pressure limit
0.0                !(dummy) maximum density
374.18  5.0787988  !reducing parameters
3 0 0 0 0 0                 !number of terms in equation
1.706155924          1.     !coefficients and exponents
0.937553068          2.
0.373002702         10.
```

```
#DV         !saturated vapor density equation
DV4  saturated vapor density equation of Tillner-Roth & Baehr (1994).
?LITERATURE REFERENCE \
?See EOS
?\
!end of info section
169.85             !lower temperature limit [K]
374.18             !upper temperature limit [K]
0.0                !(dummy) upper pressure limit
0.0                !(dummy) maximum density
374.18  5.06566567 !reducing parameters
5 0 0 0 0 0                !number of terms in equation
 -2.837294           1.     !coefficients and exponents
 -7.875988           2.
  4.478586           1.5
 -14.140125          6.75
 -52.361297          16.5
```