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From Reactor Analysis

Subject Parahydrogen 7090 Subroutines

ASTRONUCLEAR LABORATORY

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Fortran (IBM 7090) codes have been written to determine various properties of parahydrogen. The codes are in the form of Fortran subroutines and can be used as part of any Fortran program.

The following properties may be obtained from the complete package for both liquid, gas and in some cases the two phase region:

Specific Volume
Compressibility Factor
Thermal Conductivity
Specific Heat
Specific Heat Ratio
Enthalpy
Viscosity

The subroutines are described on the attached pages. The effects of parahydrogen and dissociation have been included. The properties of parahydrogen used are those agreed upon at the meeting at the National Bureau of Standards Laboratory in Boulder, Colorado, on March 28 - 29.

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VISCOSITY

(Function Subroutine)

Purpose: Determines the viscosity of hydrogen from temperature, pressure, and specific volume for both liquid and gaseous hydrogen.

Input: Temperature (T) - 25 to 9000 °R
Pressure (P) - 1.47 to 1470 psia
Specific Volume (V) - ft³/lb
LG - 0 gaseous, 1 liquid

Output: Viscosity - lb/ft sec

Units: Temperature must be in °R
Pressure must be in lb/in²
Specific Volume must be in ft³/lb

Entrance: Variable = H₂ (P, V, T, LG)
When LG = 0 gaseous hydrogen
When LG = 1 liquid hydrogen

Storage: Code (248)₁₀ plus EXPF library function

MASTER

THERMAL CONDUCTIVITY

(Function Subroutine)

Purpose: Determines the thermal conductivity of parahydrogen from temperature, pressure, and specific volume for both liquid and gaseous parahydrogen.

Input: Temperature (T) - 0 to 9000 °R
Pressure (P) - 1.47 to 1470 psia
Specific Volume (V) - ft³/lb

Output: Thermal Conductivity BTU/hr ft °R

Units: Temperature must be in °R
Pressure must be in lb/in²
Specific Volume must be in ft³/lb

Entrance: Variable = THERMK (P, V, T)

Storage: Code (500)₁₀ plus EXPF library function

ENTHALPY

Purpose: Determines the enthalpy given the pressure and temperature or determines the temperature given the pressure and enthalpy* for parahydrogen.

Input: Temperature (T) - 25 to 5400 °R
Pressure (P) - 1.47 to 1470 psia
Enthalpy (H) - BTU/lb
M = 0 Determines H from P and T
M = 1 Determines T from P and H*

Entrance: CALL ENTHAL (P, T, H, M)

Storage: Code (1275)₁₀ plus EXPF, NLOG and SQRT library functions plus DI and SI subroutines

Output: Either enthalpy or temperature depending on the value of M

Comments: Double parabolic interpolation is used below 540 °R

* The enthalpy must be greater than 100 BTU/lb to use this option.

SPECIFIC HEAT AT CONSTANT PRESSURE AND SPECIFIC HEAT RATIO

Purpose: Determines the specific heat and specific heat ratio for parahydrogen.

Input: Temperature (T) - 25 to 5400 °R
Pressure (P) - 1.47 to 1470 psia
Specific Volume (V) - any value outside of the dome

Output: Specific Heat (CP) - BTU/lb °R
Specific Heat Ratio (GA)

Entrance: CALL CPGA (P, V, T, CP, GA)

Storage: Code (195)₁₀ plus ENTHAL and PVT subroutines

PVT AND COMPRESSIBILITY

Purpose: Determines the compressibility factor and either the specific volume given pressure and temperature or pressure given the specific volume and temperature for parahydrogen.

Input: Temperature (T) - 25 to 6000 °R
Pressure (P) - near zero to 1470 psia
Specific Volume (V) - any value outside of the dome
LG = 0 gaseous, LG = 1 liquid
N = 0 Determines Z and V from T and P
N = 1 Determines Z and P from T and V

Entrance: CALL PVT (P, V, T, N, LG, Z)

Storage: Code (781)₁₀ plus EXPF, NLOG and SQRT library functions

Comments: When the code does not converge in less than 25 iterations in the liquid region the code will print out an error message and will exit with the saturated liquid value of V at the input temperature.

SPECIFIC VOLUME

Purpose: Determines the specific volume of hydrogen for liquid, two-phase and gaseous cases from the pressure, temperature and enthalpy.

Input: Temperature (T) - 25 to 6000 °R
Pressure (P) - 1.47 to 1470 psia
Enthalpy (H)

Output: Specific Volume (V) - BTU/lb
Quality (QU)
LG = 1 liquid
= 0 gaseous
= -1 two-phase

Entrance: CALL PHDØME (P, V, T, H, QU, LG)

Storage: Code (281)₁₀ plus PVT subroutine