Computer Code Abstract

WASP2

1. Program Name: WASP2—A FORTRAN-IV computer program for calculating water properties used in reactor safety analysis.

2. Computer and Programming Language: CDC-6600 and CDC-7600; FORTRAN-IV.

3. Physical Problem Solved: WASP2 (Ref. 1) is a FORTRAN-IV computer program that performs a spline function fit to data obtained from the WASP subprogram[2] for thermodynamic and transport properties of water and steam. The properties calculated by WASP2 are pressure and temperature as functions of specific volume and specific internal energy; specific volume as a function of pressure and enthalpy; and viscosity, thermal conductivity, and specific heat as functions of pressure and temperature. The pressure range covered is from below atmospheric to near critical for saturation states and for single-phase vapor, and to over 10 000 psia for single-phase liquid. The temperature range is from ~60 to 650°F for the liquid, and from saturation temperature to ~2200°F for the vapor.

4. Method of Solution: The subroutines for calculating pressure, temperature, and specific volume use cubic and bicubic spline interpolation procedures. Two types of mathematical splines are used. For one independent variable, a cubic spline is used, while for two independent variables, a bicubic spline is applied. Both splines are as described in Ref. 3, with modifications that a nonuniform mesh is allowed for the cubic spline and first derivative boundary conditions are permitted for both cubic and bicubic splines. The data points or knots for the splines are obtained from the NASA WASP program,[2] which generates very smooth surfaces.

5. Restrictions on the Complexity of the Problem: The WASP2 procedures are restricted to be within a pressure range from below atmospheric to near critical for saturation states and for single-phase vapor, and to over 10 000 psia for single-phase liquid. The temperature range is from ~60 to 650°F for the liquid, and from saturation temperature to ~2200°F for the vapor regions.

6. Related and Axiliary Programs: The source for the stored data points or knots for the spline interpolation routines is the NASA WASP program documented in Ref. 2.

7. Typical Running Time: The computer time to compute specific volume given pressure and enthalpy is 50 μs on a CDC-7600. Time to compute pressure from internal energy and specific volume is 100 μs for vapor and 45 μs for liquid on a CDC-7600.

8. Unusual Features of the Program: Cubic and bicubic splines provide a fast and accurate method for computing water properties on a large computer running long problems. The approximations also have smooth derivatives, a fact that facilitates the modeling of large systems of differential equations.

9. Status: Production.

10. Machine Requirements: The WASP2 procedure requires $200\,000_8$ words of CDC-7600 Large Core Memory or CDC-6600 Extended Core Storage for storing the coefficients for the spline functional fit of the water and steam surfaces.

11. Operating System or Monitor: The WASP2 program operates with either the SCOPE 3.3 (CDC-6600) or the SCOPE 1.1 (CDC-7600) operating system.

12. Other Programming Restrictions or Operating Information: The WASP2 edit program utilizes environmental routines INTTAP, OUTTAP, LINES, and FINISH, which are documented in Ref. 4. These routines can easily be replaced and do not require obtaining the entire programming environment.[4] A simple extended core storage routine, READEC and WRITEC, documented in Ref. 4, is used for transferring data between large and small core storage.

13. Availability: Copies of the computer program may be obtained by domestic users from

    Argonne Code Center
    Attention: Mrs. Margaret Butler
    Argonne National Laboratory
    9700 South Cass Avenue
    Argonne, Illinois 60440

14. *References*:

[1]D. A. SPRAGG, C. S. CALDWELL, F. T. DUNCKHORST, and G. W. SWARTELE, "WASP2—A FORTRAN-IV Computer Program for Calculating Water Properties Used in Reactor Safety Analysis," WAPD-TM-1211, Bettis Atomic Power Laboratory (1976).

[2]ROBERT C. HENDRICKS, ILDIKO C. PELLER, and ANNE K. BARON, "WASP—A Flexible FORTRAN-IV Computer Code for Calculating Water and Steam Properties," NASA TN D-7391, National Aeronautics and Space Administration, Lewis Research Center (1973).

[3]T. M. DAVIS and A. L. KONTIS, "Spline Interpolation for Track-Type Survey Data with Applications to the Computation of Mean Gravity Anomalies," Technical Report No. 226, Naval Oceangraphics Office (1970).

[4]W. R. CADWELL, Ed., "Reference Manual—Bettis Programming Environment," WAPD-TM-1181, Bettis Atomic Power Laboratory (1974).

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