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NASA TECH BRIEF

Lewis Research Center

Cavitation Data for Hydraulic Equipment

Calculations and tabulated data of cavitation B-factors have been developed for helium, parahydrogen, nitrogen, fluorine, oxygen, refrigerant 114, and water. The B-factor is the ratio of the vapor volume to liquid volume that would exist if a given mass of fluid, which was initially all liquid, were expanded to a larger volume without heat addition. It can be interpreted as an indicator of the extent of "vapor lock" that can occur in a liquid pump or system. In pumps (and other flowing systems), there is an upper limit to the ratio beyond which the performance of the pump (or system) is impaired because of excessive cavitation. Once the relationship between performance and B-factor has been established for a particular pump (or system) for one fluid, its behavior for another fluid is also known. Most fluids, even complex fluids like freon, behave in a similar manner from the cavitation or boiling considerations.

A brief history is given on the development of the B-factor concept and its application to the design of liquid pumps. Previous methods of computing B-factor were reviewed and a simplified, more precise computation method was established.

The basic equation to determine the B-factor is

$$B=\left(\frac{\rho_{f2}}{\rho_{v2}}\right)\left(\frac{m_{v2}}{m_{f2}}\right)=\left(\frac{\rho_{f2}}{\rho_{v2}}\right)\frac{s_{f1}-s_{f2}}{s_{v2}-s_{f1}}$$

where:

B = vapor to liquid volume ratio
m = mass
s = specific entropy
ρ = density
$f1$ = saturated liquid conditions at initial pressure
$f2$ = saturated liquid conditions at final pressure
$v2$ = saturated vapor conditions at final pressure

This expression does not rely upon summation of incremental steps to account for changing fluid properties, vaporization of liquid, or recondensation of vapor. The B-factor resulting from any finite pressure (or corresponding temperature) depression may be calculated in one simple step. The accuracy of the results is limited only by the accuracy of the liquid pressure-volume-temperature (P-V-T) data, and charts, tables, etc., may easily be developed from appropriate equations of state or tabulated thermodynamic properties.

Almost the entire saturated liquid temperature range was covered for each fluid; i.e., from temperatures just above the triple-point to temperatures just below the critical point. Under normal circumstances, the value of B-factor does not exceed a value of 5.0 without incurring excessive cavitation. However, in order to insure complete coverage of the range that might be encountered, even under unusual circumstances, the computations for each fluid were made to B-factors of at least 10.1. These computations were made at intervals of bulk fluid saturation temperature which are sufficiently small to permit interpolation to intermediate temperatures. The tabular data presentation was chosen because it provides in the most concise form the maximum temperature range, B-factor range, and precision at close initial-temperature intervals. Graphs of the desired range and precision may quickly and easily be constructed from the tabulated data.

Graphs may be constructed from the tables to determine the intermediate B-factor functions, or interpolations may be made directly from the tables.

Notes:

1. An example problem is given demonstrating the use of the tabulated data.
2. The following documentation may be obtained from:

(continued overleaf)

Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402
Price $1.00

Reference: NBS Technical Note 397 (SD Catalog No. C13.46:397), Tabulated Values of Cavitation B-Factor for Helium, H_2, N_2, F_2, O_2, Refrigerant 114, and H_2O

3. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B72-10384

Patent status:

No patent action is contemplated by NASA.

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