# Thermodynamic and Transport Properties of Fluids

# SI Units

*arranged by*

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## NOTATION AND UNITS

| | | |
|---|---|---|
| $a$ | m/s | – velocity of sound |
| $c_p, c_v$ | kJ/kg K | – specific heat (at constant $p$, constant $v$) |
| $G$ | kJ/kmol | – molar Gibbs function |
| $h$ | kJ/kg | – specific enthalpy |
| $H$ | kJ/kmol | – molar enthalpy |
| $\Delta H_0$ | kJ | – molar enthalpy of reaction ($H_{\text{prod}} - H_{\text{react}}$) |
| $k$ | kW/m K | – thermal conductivity |
| $K$ | (atm units) | – dissociation constant |
| $M$ | kg/kmol | – molar mass |
| $p$ | bar | – absolute pressure |
| $Pr$ | | – Prandtl number, $c_p \mu/k$ |
| $R$ | kJ/kg K | – specific g ; constant |
| $R_0$ | kJ/kmol K | – universal gas constant |
| $s$ | kJ/kg K | – specific entropy |
| $S$ | kJ/kmol K | – molar entropy |
| $t$ | °C | – Celsius temperature |
| $T$ | K | – absolute temperature |
| $u$ | kJ/kg | – specific internal energy |
| $U$ | kJ/kmol | – molar internal energy |
| $v$ | $m^3/kg$ | – specific volume |
| $z$ | m | – geometric altitude above sea level |
| $\gamma$ | | – ratio of specific heats, $c_p/c_v$ |
| $\lambda$ | m | – mean free path |
| $\mu$ | kg/m s = N s/$m^2$ | – dynamic viscosity |
| $\nu$ | $m^2/s$ | – kinematic viscosity, $\mu/\rho$ |
| $\rho$ | $kg/m^3$ | – density |

Subscripts and Superscripts

- a – refers to a property at standard atmospheric pressure
- $f$ – refers to a property of the saturated liquid
- $g$ – refers to a property of the saturated vapour
- $fg$ – refers to the change of phase at constant $p$
- $i$ – refers to the property of the saturated solid
- $s$ – refers to the saturation state

## Saturated Water and Steam

| $t$ [°C] | $p_s$ [bar] | $v_g$ [m³/kg] | $h_f$ [kJ/kg] | $h_{fg}$ [kJ/kg] | $h_g$ [kJ/kg] | $s_f$ [kJ/kg K] | $s_{fg}$ [kJ/kg K] | $s_g$ [kJ/kg K] |
|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.006112 | 206.1 | 0* | 2500.8 | 2500.8 | 0† | 9.155 | 9.155 |
| 1 | 0.006566 | 192.6 | 4.2 | 2498.3 | 2502.5 | 0.015 | 9.113 | 9.128 |
| 2 | 0.007054 | 179.9 | 8.4 | 2495.9 | 2504.3 | 0.031 | 9.071 | 9.102 |
| 3 | 0.007575 | 168.2 | 12.6 | 2493.6 | 2506.2 | 0.046 | 9.030 | 9.076 |
| 4 | 0.008129 | 157.3 | 16.8 | 2491.3 | 2508.1 | 0.061 | 8.989 | 9.050 |
| 5 | 0.008719 | 147.1 | 21.0 | 2488.9 | 2509.9 | 0.076 | 8.948 | 9.024 |
| 6 | 0.009346 | 137.8 | 25.2 | 2486.6 | 2511.8 | 0.091 | 8.908 | 8.999 |
| 7 | 0.01001 | 129.1 | 29.4 | 2484.3 | 2513.7 | 0.106 | 8.868 | 8.974 |
| 8 | 0.01072 | 121.0 | 33.6 | 2481.9 | 2515.5 | 0.121 | 8.828 | 8.949 |
| 9 | 0.01147 | 113.4 | 37.8 | 2479.6 | 2517.4 | 0.136 | 8.788 | 8.924 |
| 10 | 0.01227 | 106.4 | 42.0 | 2477.2 | 2519.2 | 0.151 | 8.749 | 8.900 |
| 11 | 0.01312 | 99.90 | 46.2 | 2474.9 | 2521.1 | 0.166 | 8.710 | 8.876 |
| 12 | 0.01401 | 93.83 | 50.4 | 2472.5 | 2522.9 | 0.180 | 8.671 | 8.851 |
| 13 | 0.01497 | 88.17 | 54.6 | 2470.2 | 2524.8 | 0.195 | 8.633 | 8.828 |
| 14 | 0.01597 | 82.89 | 58.8 | 2467.8 | 2526.6 | 0.210 | 8.594 | 8.804 |
| 15 | 0.01704 | 77.97 | 62.9 | 2465.5 | 2528.4 | 0.224 | 8.556 | 8.780 |
| 16 | 0.01817 | 73.38 | 67.1 | 2463.1 | 2530.2 | 0.239 | 8.518 | 8.757 |
| 17 | 0.01936 | 69.09 | 71.3 | 2460.8 | 2532.1 | 0.253 | 8.481 | 8.734 |
| 18 | 0.02063 | 65.08 | 75.5 | 2458.4 | 2533.9 | 0.268 | 8.444 | 8.712 |
| 19 | 0.02196 | 61.34 | 79.7 | 2456.0 | 2535.7 | 0.282 | 8.407 | 8.689 |
| 20 | 0.02337 | 57.84 | 83.9 | 2453.7 | 2537.6 | 0.296 | 8.370 | 8.666 |
| 21 | 0.02486 | 54.56 | 88.0 | 2451.4 | 2539.4 | 0.310 | 8.334 | 8.644 |
| 22 | 0.02642 | 51.49 | 92.2 | 2449.0 | 2541.2 | 0.325 | 8.297 | 8.622 |
| 23 | 0.02808 | 48.62 | 96.4 | 2446.6 | 2543.0 | 0.339 | 8.261 | 8.600 |
| 24 | 0.02982 | 45.92 | 100.6 | 2444.2 | 2544.8 | 0.353 | 8.226 | 8.579 |
| 25 | 0.03166 | 43.40 | 104.8 | 2441.8 | 2546.6 | 0.367 | 8.190 | 8.557 |
| 26 | 0.03360 | 41.03 | 108.9 | 2439.5 | 2548.4 | 0.381 | 8.155 | 8.536 |
| 27 | 0.03564 | 38.81 | 113.1 | 2437.2 | 2550.3 | 0.395 | 8.120 | 8.515 |
| 28 | 0.03778 | 36.73 | 117.3 | 2434.8 | 2552.1 | 0.409 | 8.085 | 8.494 |
| 29 | 0.04004 | 34.77 | 121.5 | 2432.4 | 2553.9 | 0.423 | 8.050 | 8.473 |
| 30 | 0.04242 | 32.93 | 125.7 | 2430.0 | 2555.7 | 0.436 | 8.016 | 8.452 |
| 32 | 0.04754 | 29.57 | 134.0 | 2425.3 | 2559.3 | 0.464 | 7.948 | 8.412 |
| 34 | 0.05318 | 26.60 | 142.4 | 2420.5 | 2562.9 | 0.491 | 7.881 | 8.372 |
| 36 | 0.05940 | 23.97 | 150.7 | 2415.8 | 2566.5 | 0.518 | 7.814 | 8.332 |
| 38 | 0.06624 | 21.63 | 159.1 | 2411.0 | 2570.1 | 0.545 | 7.749 | 8.294 |
| 40 | 0.07375 | 19.55 | 167.5 | 2406.2 | 2573.7 | 0.572 | 7.684 | 8.256 |
| 42 | 0.08198 | 17.69 | 175.8 | 2401.4 | 2577.2 | 0.599 | 7.620 | 8.219 |
| 44 | 0.09100 | 16.03 | 184.2 | 2396.6 | 2580.8 | 0.625 | 7.557 | 8.182 |
| 46 | 0.1009 | 14.56 | 192.5 | 2391.8 | 2584.3 | 0.651 | 7.494 | 8.145 |
| 48 | 0.1116 | 13.23 | 200.9 | 2387.0 | 2587.9 | 0.678 | 7.433 | 8.111 |
| 50 | 0.1233 | 12.04 | 209.3 | 2382.1 | 2591.4 | 0.704 | 7.371 | 8.075 |
| 55 | 0.1574 | 9.578 | 230.2 | 2370.1 | 2600.3 | 0.768 | 7.223 | 7.991 |
| 60 | 0.1992 | 7.678 | 251.1 | 2357.9 | 2609.0 | 0.831 | 7.078 | 7.909 |
| 65 | 0.2501 | 6.201 | 272.0 | 2345.7 | 2617.7 | 0.893 | 6.937 | 7.830 |
| 70 | 0.3116 | 5.045 | 293.0 | 2333.3 | 2626.3 | 0.955 | 6.800 | 7.755 |
| 75 | 0.3855 | 4.133 | 313.9 | 2320.8 | 2634.7 | 1.015 | 6.666 | 7.681 |
| 80 | 0.4736 | 3.408 | 334.9 | 2308.3 | 2643.2 | 1.075 | 6.536 | 7.611 |
| 85 | 0.5780 | 2.828 | 355.9 | 2295.6 | 2651.5 | 1.134 | 6.410 | 7.544 |
| 90 | 0.7011 | 2.361 | 376.9 | 2282.8 | 2659.7 | 1.192 | 6.286 | 7.478 |
| 95 | 0.8453 | 1.982 | 398.0 | 2269.8 | 2667.8 | 1.250 | 6.166 | 7.416 |
| 100 | 1.01325 | 1.673 | 419.1 | 2256.7 | 2675.8 | 1.307 | 6.048 | 7.355 |

† $u$ and $s$ are chosen to be zero for saturated liquid at the triple point.

Note: values of $v_f$ can be found on p. 10.

| $p$ [bar] | $t_s$ [°C] | $v_g$ [m³/kg] | $u_f$ [kJ/kg] | $u_g$ [kJ/kg] | $h_f$ [kJ/kg] | $h_{fg}$ [kJ/kg] | $h_g$ [kJ/kg] | $s_f$ [kJ/kg K] | $s_{fg}$ [kJ/kg K] | $s_g$ [kJ/kg K] |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.006112 | 0.01 | 206.1 | 0† | 2375 | 0* | 2501 | 2501 | 0† | 9.155 | 9.155 |
| 0.010 | 7.0 | 129.2 | 29 | 2385 | 29 | 2485 | 2514 | 0.106 | 8.868 | 8.974 |
| 0.015 | 13.0 | 87.98 | 55 | 2393 | 55 | 2470 | 2525 | 0.196 | 8.631 | 8.827 |
| 0.020 | 17.5 | 67.01 | 73 | 2399 | 73 | 2460 | 2533 | 0.261 | 8.462 | 8.723 |
| 0.025 | 21.1 | 54.26 | 88 | 2403 | 88 | 2451 | 2539 | 0.312 | 8.330 | 8.642 |
| 0.030 | 24.1 | 45.67 | 101 | 2408 | 101 | 2444 | 2545 | 0.354 | 8.222 | 8.576 |
| 0.035 | 26.7 | 39.48 | 112 | 2412 | 112 | 2438 | 2550 | 0.391 | 8.130 | 8.521 |
| 0.040 | 29.0 | 34.80 | 121 | 2415 | 121 | 2433 | 2554 | 0.422 | 8.051 | 8.473 |
| 0.045 | 31.0 | 31.14 | 130 | 2418 | 130 | 2428 | 2558 | 0.451 | 7.980 | 8.431 |
| 0.050 | 32.9 | 28.20 | 138 | 2420 | 138 | 2423 | 2561 | 0.476 | 7.918 | 8.394 |
| 0.055 | 34.6 | 25.77 | 145 | 2422 | 145 | 2419 | 2564 | 0.500 | 7.860 | 8.360 |
| 0.060 | 36.2 | 23.74 | 152 | 2425 | 152 | 2415 | 2567 | 0.521 | 7.808 | 8.329 |
| 0.065 | 37.7 | 22.02 | 158 | 2427 | 158 | 2412 | 2570 | 0.541 | 7.760 | 8.301 |
| 0.070 | 39.0 | 20.53 | 163 | 2428 | 163 | 2409 | 2572 | 0.559 | 7.715 | 8.274 |
| 0.075 | 40.3 | 19.24 | 169 | 2430 | 169 | 2405 | 2574 | 0.576 | 7.674 | 8.250 |
| 0.080 | 41.5 | 18.10 | 174 | 2432 | 174 | 2402 | 2576 | 0.593 | 7.634 | 8.227 |
| 0.085 | 42.7 | 17.10 | 179 | 2434 | 179 | 2400 | 2579 | 0.608 | 7.598 | 8.206 |
| 0.090 | 43.8 | 16.20 | 183 | 2435 | 183 | 2397 | 2580 | 0.622 | 7.564 | 8.186 |
| 0.095 | 44.8 | 15.40 | 188 | 2436 | 188 | 2394 | 2582 | 0.636 | 7.531 | 8.167 |
| 0.100 | 45.8 | 14.67 | 192 | 2437 | 192 | 2392 | 2584 | 0.649 | 7.500 | 8.149 |
| 0.12 | 49.4 | 12.36 | 207 | 2442 | 207 | 2383 | 2590 | 0.696 | 7.389 | 8.085 |
| 0.14 | 52.6 | 10.69 | 220 | 2446 | 220 | 2376 | 2596 | 0.737 | 7.294 | 8.031 |
| 0.16 | 55.3 | 9.432 | 232 | 2450 | 232 | 2369 | 2601 | 0.772 | 7.213 | 7.985 |
| 0.18 | 57.8 | 8.444 | 242 | 2453 | 242 | 2363 | 2605 | 0.804 | 7.140 | 7.944 |
| 0.20 | 60.1 | 7.648 | 251 | 2456 | 251 | 2358 | 2609 | 0.832 | 7.075 | 7.907 |
| 0.22 | 62.2 | 6.994 | 260 | 2459 | 260 | 2353 | 2613 | 0.858 | 7.016 | 7.874 |
| 0.24 | 64.1 | 6.445 | 268 | 2461 | 268 | 2348 | 2616 | 0.882 | 6.962 | 7.844 |
| 0.26 | 65.9 | 5.979 | 276 | 2464 | 276 | 2343 | 2619 | 0.904 | 6.913 | 7.817 |
| 0.28 | 67.5 | 5.578 | 283 | 2466 | 283 | 2339 | 2622 | 0.925 | 6.866 | 7.791 |
| 0.30 | 69.1 | 5.228 | 289 | 2468 | 289 | 2336 | 2625 | 0.944 | 6.823 | 7.767 |
| 0.32 | 70.6 | 4.921 | 295 | 2470 | 295 | 2332 | 2627 | 0.962 | 6.783 | 7.745 |
| 0.34 | 72.0 | 4.649 | 302 | 2472 | 302 | 2328 | 2630 | 0.980 | 6.745 | 7.725 |
| 0.36 | 73.4 | 4.407 | 307 | 2473 | 307 | 2325 | 2632 | 0.996 | 6.709 | 7.705 |
| 0.38 | 74.7 | 4.189 | 312 | 2475 | 312 | 2322 | 2634 | 1.011 | 6.675 | 7.686 |
| 0.40 | 75.9 | 3.992 | 318 | 2476 | 318 | 2318 | 2636 | 1.026 | 6.643 | 7.669 |
| 0.42 | 77.1 | 3.814 | 323 | 2478 | 323 | 2315 | 2638 | 1.040 | 6.612 | 7.652 |
| 0.44 | 78.2 | 3.651 | 327 | 2479 | 327 | 2313 | 2640 | 1.054 | 6.582 | 7.636 |
| 0.46 | 79.3 | 3.502 | 332 | 2481 | 332 | 2310 | 2642 | 1.067 | 6.554 | 7.621 |
| 0.48 | 80.3 | 3.366 | 336 | 2482 | 336 | 2308 | 2644 | 1.079 | 6.528 | 7.607 |
| 0.50 | 81.3 | 3.239 | 340 | 2483 | 340 | 2305 | 2645 | 1.091 | 6.502 | 7.593 |
| 0.55 | 83.7 | 2.964 | 351 | 2486 | 351 | 2298 | 2649 | 1.119 | 6.442 | 7.561 |
| 0.60 | 86.0 | 2.731 | 360 | 2489 | 360 | 2293 | 2653 | 1.145 | 6.386 | 7.531 |
| 0.65 | 88.0 | 2.535 | 369 | 2492 | 369 | 2288 | 2657 | 1.169 | 6.335 | 7.504 |
| 0.70 | 90.0 | 2.364 | 377 | 2494 | 377 | 2283 | 2660 | 1.192 | 6.286 | 7.478 |
| 0.75 | 91.8 | 2.217 | 384 | 2496 | 384 | 2278 | 2662 | 1.213 | 6.243 | 7.456 |
| 0.80 | 93.5 | 2.087 | 392 | 2498 | 392 | 2273 | 2665 | 1.233 | 6.201 | 7.434 |
| 0.85 | 95.2 | 1.972 | 399 | 2500 | 399 | 2269 | 2668 | 1.252 | 6.162 | 7.414 |
| 0.90 | 96.7 | 1.869 | 405 | 2502 | 405 | 2266 | 2671 | 1.270 | 6.124 | 7.394 |
| 0.95 | 98.2 | 1.777 | 411 | 2504 | 411 | 2262 | 2673 | 1.287 | 6.089 | 7.376 |
| 1.00 | 99.6 | 1.694 | 417 | 2506 | 417 | 2258 | 2675 | 1.303 | 6.056 | 7.359 |

* $\dfrac{h_f}{[\text{kJ/kg}]} = \dfrac{pv_f}{[\text{kJ/kg}]} = \dfrac{p}{[\text{bar}]} \times \dfrac{10^5[\text{N}]}{[\text{m}^2]} \times \dfrac{v_f}{[\text{m}^3/\text{kg}]} \times \left[\dfrac{\text{m}^3}{\text{kg}}\right] \times \dfrac{[\text{kJ}]}{10^3[\text{N m}]} \times \dfrac{1}{[\text{kJ/kg}]}$

$= \dfrac{p}{[\text{bar}]} \times \dfrac{v_f}{[\text{m}^3/\text{kg}]} \times 10^2 = 0.006112 \times 0.0010002 \times 10^2 = 0.0006112$

## Saturated Water and Steam

| $p$ [bar] | $t_s$ [°C] | $v_g$ [m³/kg] | $u_f$ [kJ/kg] | $u_g$ [kJ/kg] | $h_f$ [kJ/kg] | $h_{fg}$ [kJ/kg] | $h_g$ [kJ/kg] | $s_f$ [kJ/kg K] | $s_{fg}$ [kJ/kg K] | $s_g$ [kJ/kg K] |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | 99.6 | 1.694 | 417 | 2506 | 417 | 2258 | 2675 | 1.303 | 6.056 | 7.359 |
| 1.1 | 102.3 | 1.549 | 429 | 2510 | 429 | 2251 | 2680 | 1.333 | 5.994 | 7.327 |
| 1.2 | 104.8 | 1.428 | 439 | 2512 | 439 | 2244 | 2683 | 1.361 | 5.937 | 7.298 |
| 1.3 | 107.1 | 1.325 | 449 | 2515 | 449 | 2238 | 2687 | 1.387 | 5.884 | 7.271 |
| 1.4 | 109.3 | 1.236 | 458 | 2517 | 458 | 2232 | 2690 | 1.411 | 5.835 | 7.246 |
| 1.5 | 111.4 | 1.159 | 467 | 2519 | 467 | 2226 | 2693 | 1.434 | 5.789 | 7.223 |
| 1.6 | 113.3 | 1.091 | 475 | 2521 | 475 | 2221 | 2696 | 1.455 | 5.747 | 7.202 |
| 1.7 | 115.2 | 1.031 | 483 | 2524 | 483 | 2216 | 2699 | 1.475 | 5.707 | 7.182 |
| 1.8 | 116.9 | 0.9774 | 491 | 2526 | 491 | 2211 | 2702 | 1.494 | 5.669 | 7.163 |
| 1.9 | 118.6 | 0.9292 | 498 | 2528 | 498 | 2206 | 2704 | 1.513 | 5.632 | 7.145 |
| 2.0 | 120.2 | 0.8856 | 505 | 2530 | 505 | 2202 | 2707 | 1.530 | 5.597 | 7.127 |
| 2.1 | 121.8 | 0.8461 | 511 | 2531 | 511 | 2198 | 2709 | 1.547 | 5.564 | 7.111 |
| 2.2 | 123.3 | 0.8100 | 518 | 2533 | 518 | 2193 | 2711 | 1.563 | 5.533 | 7.096 |
| 2.3 | 124.7 | 0.7770 | 524 | 2534 | 524 | 2189 | 2713 | 1.578 | 5.503 | 7.081 |
| 2.4 | 126.1 | 0.7466 | 530 | 2536 | 530 | 2185 | 2715 | 1.593 | 5.474 | 7.067 |
| 2.5 | 127.4 | 0.7186 | 535 | 2537 | 535 | 2182 | 2717 | 1.607 | 5.446 | 7.053 |
| 2.6 | 128.7 | 0.6927 | 541 | 2539 | 541 | 2178 | 2719 | 1.621 | 5.419 | 7.040 |
| 2.7 | 130.0 | 0.6686 | 546 | 2540 | 546 | 2174 | 2720 | 1.634 | 5.393 | 7.027 |
| 2.8 | 131.2 | 0.6462 | 551 | 2541 | 551 | 2171 | 2722 | 1.647 | 5.368 | 7.015 |
| 2.9 | 132.4 | 0.6253 | 556 | 2543 | 556 | 2168 | 2724 | 1.660 | 5.344 | 7.004 |
| 3.0 | 133.5 | 0.6057 | 561 | 2544 | 561 | 2164 | 2725 | 1.672 | 5.321 | 6.993 |
| 3.5 | 138.9 | 0.5241 | 584 | 2549 | 584 | 2148 | 2732 | 1.727 | 5.214 | 6.941 |
| 4.0 | 143.6 | 0.4623 | 605 | 2554 | 605 | 2134 | 2739 | 1.776 | 5.121 | 6.897 |
| 4.5 | 147.9 | 0.4139 | 623 | 2558 | 623 | 2121 | 2744 | 1.820 | 5.037 | 6.857 |
| 5.0 | 151.8 | 0.3748 | 639 | 2562 | 640 | 2109 | 2749 | 1.860 | 4.962 | 6.822 |
| 5.5 | 155.5 | 0.3427 | 655 | 2565 | 656 | 2097 | 2753 | 1.897 | 4.893 | 6.790 |
| 6 | 158.8 | 0.3156 | 669 | 2568 | 670 | 2087 | 2757 | 1.931 | 4.830 | 6.761 |
| 7 | 165.0 | 0.2728 | 696 | 2573 | 697 | 2067 | 2764 | 1.992 | 4.717 | 6.709 |
| 8 | 170.4 | 0.2403 | 720 | 2577 | 721 | 2048 | 2769 | 2.046 | 4.617 | 6.663 |
| 9 | 175.4 | 0.2149 | 742 | 2581 | 743 | 2031 | 2774 | 2.094 | 4.529 | 6.623 |
| 10 | 179.9 | 0.1944 | 762 | 2584 | 763 | 2015 | 2778 | 2.138 | 4.448 | 6.586 |
| 11 | 184.1 | 0.1774 | 780 | 2586 | 781 | 2000 | 2781 | 2.179 | 4.375 | 6.554 |
| 12 | 188.0 | 0.1632 | 797 | 2588 | 798 | 1986 | 2784 | 2.216 | 4.307 | 6.523 |
| 13 | 191.6 | 0.1512 | 813 | 2590 | 815 | 1972 | 2787 | 2.251 | 4.244 | 6.495 |
| 14 | 195.0 | 0.1408 | 828 | 2593 | 830 | 1960 | 2790 | 2.284 | 4.185 | 6.469 |
| 15 | 198.3 | 0.1317 | 843 | 2595 | 845 | 1947 | 2792 | 2.315 | 4.130 | 6.445 |
| 16 | 201.4 | 0.1237 | 857 | 2596 | 859 | 1935 | 2794 | 2.344 | 4.078 | 6.422 |
| 17 | 204.3 | 0.1167 | 870 | 2597 | 872 | 1923 | 2795 | 2.372 | 4.028 | 6.400 |
| 18 | 207.1 | 0.1104 | 883 | 2598 | 885 | 1912 | 2797 | 2.398 | 3.981 | 6.379 |
| 19 | 209.8 | 0.1047 | 895 | 2599 | 897 | 1901 | 2798 | 2.423 | 3.936 | 6.359 |
| 20 | 212.4 | 0.09957 | 907 | 2600 | 909 | 1890 | 2799 | 2.447 | 3.893 | 6.340 |
| 22 | 217.2 | 0.09069 | 928 | 2601 | 931 | 1870 | 2801 | 2.492 | 3.813 | 6.305 |
| 24 | 221.8 | 0.08323 | 949 | 2602 | 952 | 1850 | 2802 | 2.534 | 3.738 | 6.272 |
| 26 | 226.0 | 0.07689 | 969 | 2603 | 972 | 1831 | 2803 | 2.574 | 3.668 | 6.242 |
| 28 | 230.0 | 0.07142 | 988 | 2603 | 991 | 1812 | 2803 | 2.611 | 3.602 | 6.213 |
| 30 | 233.8 | 0.06665 | 1004 | 2603 | 1008 | 1795 | 2803 | 2.645 | 3.541 | 6.186 |
| 32 | 237.4 | 0.06246 | 1021 | 2603 | 1025 | 1778 | 2803 | 2.679 | 3.482 | 6.161 |
| 34 | 240.9 | 0.05875 | 1038 | 2603 | 1042 | 1761 | 2803 | 2.710 | 3.426 | 6.136 |
| 36 | 244.2 | 0.05544 | 1054 | 2602 | 1058 | 1744 | 2802 | 2.740 | 3.373 | 6.113 |
| 38 | 247.3 | 0.05246 | 1068 | 2602 | 1073 | 1729 | 2802 | 2.769 | 3.322 | 6.091 |
| 40 | 250.3 | 0.04977 | 1082 | 2602 | 1087 | 1714 | 2801 | 2.797 | 3.273 | 6.070 |

| $p$ [bar] | $t_s$ [°C] | $v_g$ [m³/kg] | $u_f$ [kJ/kg] | $u_g$ [kJ/kg] | $h_f$ [kJ/kg] | $h_{fg}$ [kJ/kg] | $h_g$ [kJ/kg] | $s_f$ [kJ/kg K] | $s_{fg}$ [kJ/kg K] | $s_g$ [kJ/kg K] |
|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 250.3 | 0.04977 | 1082 | 2602 | 1087 | 1714 | 2801 | 2.797 | 3.273 | 6.070 |
| 42 | 253.2 | 0.04732 | 1097 | 2601 | 1102 | 1698 | 2800 | 2.823 | 3,226 | 6.049 |
| 44 | 256.0 | 0.04509 | 1109 | 2600 | 1115 | 1683 | 2798 | 2.849 | 3.180 | 6.029 |
| 46 | 258.8 | 0.04305 | 1123 | 2599 | 1129 | 1668 | 2797 | 2.874 | 3.136 | 6.010 |
| 48 | 261.4 | 0.04117 | 1136 | 2598 | 1142 | 1654 | 2796 | 2.897 | 3.094 | 5.991 |
| 50 | 263.9 | 0.03944 | 1149 | 2597 | 1155 | 1639 | 2794 | 2.921 | 3.052 | 5.973 |
| 55 | 269.9 | 0.03563 | 1178 | 2594 | 1185 | 1605 | 2790 | 2.976 | 2.955 | 5.931 |
| 60 | 275.6 | 0.03244 | 1206 | 2590 | 1214 | 1570 | 2784 | 3.027 | 2.863 | 5.890 |
| 65 | 280.8 | 0.02972 | 1232 | 2586 | 1241 | 1538 | 2779 | 3.076 | 2.775 | 5.851 |
| 70 | 285.8 | 0.02737 | 1258 | 2581 | 1267 | 1505 | 2772 | 3.122 | 2.692 | 5.814 |
| 75 | 290.5 | 0.02532 | 1283 | 2576 | 1293 | 1473 | 2766 | 3.166 | 2.613 | 5.779 |
| 80 | 295.0 | 0.02352 | 1306 | 2570 | 1317 | 1441 | 2758 | 3.207 | 2.537 | 5.744 |
| 85 | 299.2 | 0.02192 | 1329 | 2565 | 1341 | 1410 | 2751 | 3.248 | 2.463 | 5.711 |
| 90 | 303.3 | 0.02048 | 1351 | 2559 | 1364 | 1379 | 2743 | 3.286 | 2.393 | 5.679 |
| 95 | 307.2 | 0.01919 | 1372 | 2552 | 1386 | 1348 | 2734 | 3.324 | 2.323 | 5.647 |
| 100 | 311.0 | 0.01802 | 1393 | 2545 | 1408 | 1317 | 2725 | 3.360 | 2.255 | 5.615 |
| 105 | 314.6 | 0.01696 | 1414 | 2537 | 1429 | 1286 | 2715 | 3.395 | 2.189 | 5.584 |
| 110 | 318.0 | 0.01598 | 1434 | 2529 | 1450 | 1255 | 2705 | 3.430 | 2.123 | 5.553 |
| 115 | 321.4 | 0.01508 | 1454 | 2522 | 1471 | 1224 | 2695 | 3.463 | 2.060 | 5.523 |
| 120 | 324.6 | 0.01426 | 1473 | 2514 | 1491 | 1194 | 2685 | 3.496 | 1.997 | 5.493 |
| 125 | 327.8 | 0.01349 | 1492 | 2505 | 1511 | 1163 | 2674 | 3.529 | 1.934 | 5.463 |
| 130 | 330.8 | 0.01278 | 1511 | 2496 | 1531 | 1131 | 2662 | 3.561 | 1.872 | 5.433 |
| 135 | 333.8 | 0.01211 | 1530 | 2487 | 1551 | 1099 | 2650 | 3.592 | 1.811 | 5.403 |
| 140 | 336.6 | 0.01149 | 1548 | 2477 | 1571 | 1067 | 2638 | 3.623 | 1.750 | 5.373 |
| 145 | 339.4 | 0.01090 | 1567 | 2467 | 1591 | 1034 | 2625 | 3.654 | 1.689 | 5.343 |
| 150 | 342.1 | 0.01035 | 1585 | 2456 | 1610 | 1001 | 2611 | 3.685 | 1.627 | 5.312 |
| 155 | 344.8 | 0.00982 | 1604 | 2445 | 1630 | 967 | 2597 | 3.715 | 1.565 | 5.280 |
| 160 | 347.3 | 0.00932 | 1623 | 2433 | 1650 | 932 | 2582 | 3.746 | 1.502 | 5.248 |
| 165 | 349.8 | 0.00884 | 1641 | 2420 | 1670 | 895 | 2565 | 3.777 | 1.437 | 5.214 |
| 170 | 352.3 | 0.00838 | 1660 | 2406 | 1690 | 858 | 2548 | 3.808 | 1.373 | 5.181 |
| 175 | 354.6 | 0.00794 | 1679 | 2391 | 1711 | 819 | 2530 | 3.839 | 1.305 | 5.144 |
| 180 | 357.0 | 0.00751 | 1699 | 2375 | 1732 | 778 | 2510 | 3.872 | 1.236 | 5.108 |
| 185 | 359.2 | 0.00709 | 1719 | 2358 | 1754 | 735 | 2489 | 3.905 | 1.163 | 5.068 |
| 190 | 361.4 | 0.00668 | 1740 | 2339 | 1777 | 689 | 2466 | 3.941 | 1.086 | 5.027 |
| 195 | 363.6 | 0.00627 | 1762 | 2318 | 1801 | 639 | 2440 | 3.977 | 1.004 | 4.981 |
| 200 | 365.7 | 0.00585 | 1786 | 2294 | 1827 | 584 | 2411 | 4.014 | 0.914 | 4.928 |
| 202 | 366.5 | 0.00569 | 1796 | 2283 | 1838 | 560 | 2398 | 4.031 | 0.875 | 4.906 |
| 204 | 367.4 | 0.00552 | 1806 | 2271 | 1849 | 535 | 2384 | 4.049 | 0.835 | 4.884 |
| 206 | 368.2 | 0.00534 | 1817 | 2259 | 1861 | 508 | 2369 | 4.067 | 0.792 | 4.859 |
| 208 | 369.0 | 0.00517 | 1829 | 2245 | 1874 | 479 | 2353 | 4.087 | 0.745 | 4.832 |
| 210 | 369.8 | 0.00498 | 1842 | 2231 | 1889 | 447 | 2336 | 4.108 | 0.695 | 4.803 |
| 212 | 370.6 | 0.00479 | 1856 | 2214 | 1904 | 412 | 2316 | 4.131 | 0.640 | 4.771 |
| 214 | 371.4 | 0.00458 | 1871 | 2196 | 1921 | 373 | 2294 | 4.157 | 0.579 | 4.736 |
| 216 | 372.1 | 0.00436 | 1888 | 2174 | 1940 | 328 | 2268 | 4.186 | 0.508 | 4.694 |
| 218 | 372.9 | 0.00409 | 1911 | 2146 | 1965 | 270 | 2235 | 4.224 | 0.417 | 4.641 |
| 220 | 373.7 | 0.00368 | 1949 | 2097 | 2008 | 170 | 2178 | 4.289 | 0.263 | 4.552 |
| 221.2 | 374.15 | 0.00317 | 2014 | 2014 | 2084 | 0 | 2084 | 4.406 | 0.000 | 4.406 |

## Superheated Steam

| $p$/[bar] ($t_s$/[°C]) | | $\frac{t}{[°C]}$ | 50 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $v$ | | | | | | | | |
| 0 | $u=h-RT$ | $u$ | 2446 | 2517 | 2589 | 2662 | 2737 | 2812 | 2969 | 3132 |
| | | $h$ | 2595 | 2689 | 2784 | 2880 | 2978 | 3077 | 3280 | 3489 |
| | | $s$ | | | | | | | | |
| | $v_g$ 206.1 | $v$ | 243.9 | 281.7 | 319.5 | 357.3 | 395.0 | 432.8 | 508.3 | 583.8 |
| 0.006112 | $u_g$ 2375 | $u$ | 2446 | 2517 | 2589 | 2662 | 2737 | 2812 | 2969 | 3132 |
| (0.01) | $h_g$ 2501 | $h$ | 2595 | 2689 | 2784 | 2880 | 2978 | 3077 | 3280 | 3489 |
| | $s_g$ 9.155 | $s$ | 9.468 | 9.739 | 9.978 | 10.193 | 10.390 | 10.571 | 10.897 | 11.187 |
| | $v_g$ 129.2 | $v$ | 149.1 | 172.2 | 195.3 | 218.4 | 241.4 | 264.5 | 310.7 | 356.8 |
| 0.01 | $u_g$ 2385 | $u$ | 2446 | 2517 | 2589 | 2662 | 2737 | 2812 | 2969 | 3132 |
| (7.0) | $h_g$ 2514 | $h$ | 2595 | 2689 | 2784 | 2880 | 2978 | 3077 | 3280 | 3489 |
| | $s_g$ 8.974 | $s$ | 9.241 | 9.512 | 9.751 | 9.966 | 10.163 | 10.344 | 10.670 | 10.960 |
| | $v_g$ 28.20 | $v$ | 29.78 | 34.42 | 39.04 | 43.66 | 48.28 | 52.90 | 62.13 | 71.36 |
| 0.05 | $u_g$ 2420 | $u$ | 2445 | 2516 | 2589 | 2662 | 2737 | 2812 | 2969 | 3132 |
| (32.9) | $h_g$ 2561 | $h$ | 2594 | 2688 | 2784 | 2880 | 2978 | 3077 | 3280 | 3489 |
| | $s_g$ 8.394 | $s$ | 8.496 | 8.768 | 9.008 | 9.223 | 9.420 | 9.601 | 9.927 | 10.217 |
| | $v_g$ 14.67 | $v$ | 14.87 | 17.20 | 19.51 | 21.83 | 24.14 | 26.45 | 31.06 | 35.68 |
| 0.1 | $u_g$ 2437 | $u$ | 2443 | 2516 | 2588 | 2662 | 2736 | 2812 | 2969 | 3132 |
| (45.8) | $h_g$ 2584 | $h$ | 2592 | 2688 | 2783 | 2880 | 2977 | 3077 | 3280 | 3489 |
| | $s_g$ 8.149 | $s$ | 8.173 | 8.447 | 8.688 | 8.903 | 9.100 | 9.281 | 9.607 | 9.897 |
| | $v_g$ 3.239 | $v$ | | 3.420 | 3.890 | 4.356 | 4.821 | 5.284 | 6.209 | 7.134 |
| 0.5 | $u_g$ 2483 | $u$ | | 2512 | 2585 | 2660 | 2735 | 2812 | 2969 | 3132 |
| (81.3) | $h_g$ 2645 | $h$ | | 2683 | 2780 | 2878 | 2976 | 3076 | 3279 | 3489 |
| | $s_g$ 7.593 | $s$ | | 7.694 | 7.940 | 8.158 | 8.355 | 8.537 | 8.864 | 9.154 |
| | $v_g$ 2.217 | $v$ | | 2.271 | 2.588 | 2.901 | 3.211 | 3.521 | 4.138 | 4.755 |
| 0.75 | $u_g$ 2496 | $u$ | | 2510 | 2585 | 2659 | 2734 | 2811 | 2969 | 3132 |
| (91.8) | $h_g$ 2662 | $h$ | | 2680 | 2779 | 2877 | 2975 | 3075 | 3279 | 3489 |
| | $s_g$ 7.456 | $s$ | | 7.500 | 7.750 | 7.969 | 8.167 | 8.349 | 8.676 | 8.967 |
| | $v_g$ 1.694 | $v$ | | 1.696 | 1.937 | 2.173 | 2.406 | 2.639 | 3.103 | 3.565 |
| 1 | $u_g$ 2506 | $u$ | | 2506 | 2583 | 2659 | 2734 | 2811 | 2968 | 3131 |
| (99.6) | $h_g$ 2675 | $h$ | | 2676 | 2777 | 2876 | 2975 | 3075 | 3278 | 3488 |
| | $s_g$ 7.359 | $s$ | | 7.360 | 7.614 | 7.834 | 8.033 | 8.215 | 8.543 | 8.834 |
| | $v_g$ 1.673 | $v$ | | | 1.912 | 2.145 | 2.375 | 2.604 | 3.062 | 3.519 |
| 1.01325 | $u_g$ 2506 | $u$ | | | 2583 | 2659 | 2734 | 2811 | 2968 | 3131 |
| (100.0) | $h_g$ 2676 | $h$ | | | 2777 | 2876 | 2975 | 3075 | 3278 | 3488 |
| | $s_g$ 7.355 | $s$ | | | 7.608 | 7.828 | 8.027 | 8.209 | 8.537 | 8.828 |
| | $v_g$ 1.159 | $v$ | | | 1.286 | 1.445 | 1.601 | 1.757 | 2.067 | 2.376 |
| 1.5 | $u_g$ 2519 | $u$ | | | 2580 | 2656 | 2733 | 2809 | 2967 | 3131 |
| (111.4) | $h_g$ 2693 | $h$ | | | 2773 | 2873 | 2973 | 3073 | 3277 | 3488 |
| | $s_g$ 7.223 | $s$ | | | 7.420 | 7.643 | 7.843 | 8.027 | 8.355 | 8.646 |
| | $v_g$ 0.8856 | $v$ | | | 0.9602 | 1.081 | 1.199 | 1.316 | 1.549 | 1.781 |
| 2 | $u_g$ 2530 | $u$ | | | 2578 | 2655 | 2731 | 2809 | 2967 | 3131 |
| (120.2) | $h_g$ 2707 | $h$ | | | 2770 | 2871 | 2971 | 3072 | 3277 | 3487 |
| | $s_g$ 7.127 | $s$ | | | 7.280 | 7.507 | 7.708 | 7.892 | 8.221 | 8.513 |
| | $v_g$ 0.6057 | $v$ | | | 0.6342 | 0.7166 | 0.7965 | 0.8754 | 1.031 | 1.187 |
| 3 | $u_g$ 2544 | $u$ | | | 2572 | 2651 | 2729 | 2807 | 2966 | 3130 |
| (133.5) | $h_g$ 2725 | $h$ | | | 2762 | 2866 | 2968 | 3070 | 3275 | 3486 |
| | $s_g$ 6.993 | $s$ | | | 7.078 | 7.312 | 7.517 | 7.702 | 8.032 | 8.324 |
| | $v_g$ 0.4623 | $v$ | | | 0.4710 | 0.5345 | 0.5953 | 0.6549 | 0.7725 | 0.8893 |
| 4 | $u_g$ 2554 | $u$ | | | 2565 | 2648 | 2727 | 2805 | 2965 | 3129 |
| (143.6) | $h_g$ 2739 | $h$ | | | 2753 | 2862 | 2965 | 3067 | 3274 | 3485 |
| | $s_g$ 6.897 | $s$ | | | 6.929 | 7.172 | 7.379 | 7.566 | 7.898 | 8.191 |

| $p$/[bar] ($t_s$/[°C]) | | | $\frac{t}{[°C]}$ | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 600 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $v_g$ | 0.3748 | $v$ | 0.4252 | 0.4745 | 0.5226 | 0.5701 | 0.6172 | 0.6641 | 0.7108 | 0.8040 |
| 5 | $u_g$ | 2562 | $u$ | 2644 | 2725 | 2804 | 2883 | 2963 | 3045 | 3129 | 3300 |
| (151.8) | $h_g$ | 2749 | $h$ | 2857 | 2962 | 3065 | 3168 | 3272 | 3377 | 3484 | 3702 |
| | $s_g$ | 6.822 | $s$ | 7.060 | 7.271 | 7.460 | 7.633 | 7.793 | 7.944 | 8.087 | 8.351 |
| | $v_g$ | 0.3156 | $v$ | 0.3522 | 0.3940 | 0.4344 | 0.4743 | 0.5136 | 0.5528 | 0.5919 | 0.6697 |
| 6 | $u_g$ | 2568 | $u$ | 2640 | 2722 | 2801 | 2881 | 2962 | 3044 | 3128 | 3299 |
| (158.8) | $h_g$ | 2757 | $h$ | 2851 | 2958 | 3062 | 3166 | 3270 | 3376 | 3483 | 3701 |
| | $s_g$ | 6.761 | $s$ | 6.968 | 7.182 | 7.373 | 7.546 | 7.707 | 7.858 | 8.001 | 8.267 |
| | $v_g$ | 0.2728 | $v$ | 0.3001 | 0.3364 | 0.3714 | 0.4058 | 0.4397 | 0.4734 | 0.5069 | 0.5737 |
| 7 | $u_g$ | 2573 | $u$ | 2636 | 2720 | 2800 | 2880 | 2961 | 3043 | 3127 | 3298 |
| (165.0) | $h_g$ | 2764 | $h$ | 2846 | 2955 | 3060 | 3164 | 3269 | 3374 | 3482 | 3700 |
| | $s_g$ | 6.709 | $s$ | 6.888 | 7.106 | 7.298 | 7.473 | 7.634 | 7.786 | 7.929 | 8.195 |
| | $v_g$ | 0.2403 | $v$ | 0.2610 | 0.2933 | 0.3242 | 0.3544 | 0.3842 | 0.4138 | 0.4432 | 0.5018 |
| 8 | $u_g$ | 2577 | $u$ | 2631 | 2716 | 2798 | 2878 | 2960 | 3042 | 3126 | 3298 |
| (170.4) | $h_g$ | 2769 | $h$ | 2840 | 2951 | 3057 | 3162 | 3267 | 3373 | 3481 | 3699 |
| | $s_g$ | 6.663 | $s$ | 6.817 | 7.040 | 7.233 | 7.409 | 7.571 | 7.723 | 7.866 | 8.132 |
| | $v_g$ | 0.2149 | $v$ | 0.2305 | 0.2597 | 0.2874 | 0.3144 | 0.3410 | 0.3674 | 0.3937 | 0.4458 |
| 9 | $u_g$ | 2581 | $u$ | 2628 | 2714 | 2796 | 2877 | 2959 | 3041 | 3126 | 3298 |
| (175.4) | $h_g$ | 2774 | $h$ | 2835 | 2948 | 3055 | 3160 | 3266 | 3372 | 3480 | 3699 |
| | $s_g$ | 6.623 | $s$ | 6.753 | 6.980 | 7.176 | 7.352 | 7.515 | 7.667 | 7.811 | 8.077 |
| | $v_g$ | 0.1944 | $v$ | 0.2061 | 0.2328 | 0.2580 | 0.2825 | 0.3065 | 0.3303 | 0.3540 | 0.4010 |
| 10 | $u_g$ | 2584 | $u$ | 2623 | 2711 | 2794 | 2875 | 2957 | 3040 | 3124 | 3297 |
| (179.9) | $h_g$ | 2778 | $h$ | 2829 | 2944 | 3052 | 3158 | 3264 | 3370 | 3478 | 3698 |
| | $s_g$ | 6.586 | $s$ | 6.695 | 6.926 | 7.124 | 7.301 | 7.464 | 7.617 | 7.761 | 8.028 |
| | $v_g$ | 0.1317 | $v$ | 0.1324 | 0.1520 | 0.1697 | 0.1865 | 0.2029 | 0.2191 | 0.2351 | 0.2667 |
| 15 | $u_g$ | 2595 | $u$ | 2597 | 2697 | 2784 | 2868 | 2952 | 3035 | 3120 | 3294 |
| (198.3) | $h_g$ | 2792 | $h$ | 2796 | 2925 | 3039 | 3148 | 3256 | 3364 | 3473 | 3694 |
| | $s_g$ | 6.445 | $s$ | 6.452 | 6.711 | 6.919 | 7.102 | 7.268 | 7.423 | 7.569 | 7.838 |
| | $v_g$ | 0.0996 | $v$ | | 0.1115 | 0.1255 | 0.1386 | 0.1511 | 0.1634 | 0.1756 | 0.1995 |
| 20 | $u_g$ | 2600 | $u$ | | 2681 | 2774 | 2861 | 2946 | 3030 | 3116 | 3291 |
| (212.4) | $h_g$ | 2799 | $h$ | | 2904 | 3025 | 3138 | 3248 | 3357 | 3467 | 3690 |
| | $s_g$ | 6.340 | $s$ | | 6.547 | 6.768 | 6.957 | 7.126 | 7.283 | 7.431 | 7.701 |
| | $v_g$ | 0.0666 | $v$ | | 0.0706 | 0.0812 | 0.0905 | 0.0993 | 0.1078 | 0.1161 | 0.1324 |
| 30 | $u_g$ | 2603 | $u$ | | 2646 | 2751 | 2845 | 2933 | 3020 | 3108 | 3285 |
| (233.8) | $h_g$ | 2803 | $h$ | | 2858 | 2995 | 3117 | 3231 | 3343 | 3456 | 3682 |
| | $s_g$ | 6.186 | $s$ | | 6.289 | 6.541 | 6.744 | 6.921 | 7.082 | 7.233 | 7.507 |
| | $v_g$ | 0.0498 | $v$ | | | 0.0588 | 0.0664 | 0.0733 | 0.0800 | 0.0864 | 0.0988 |
| 40 | $u_g$ | 2602 | $u$ | | | 2728 | 2828 | 2921 | 3010 | 3099 | 3279 |
| (250.3) | $h_g$ | 2801 | $h$ | | | 2963 | 3094 | 3214 | 3330 | 3445 | 3674 |
| | $s_g$ | 6.070 | $s$ | | | 6.364 | 6.584 | 6.769 | 6.935 | 7.089 | 7.368 |
| | $v_g$ | 0.0394 | $v$ | | | 0.0453 | 0.0519 | 0.0578 | 0.0632 | 0.0685 | 0.0786 |
| 50 | $u_g$ | 2597 | $u$ | | | 2700 | 2810 | 2907 | 3000 | 3090 | 3273 |
| (263.9) | $h_g$ | 2794 | $h$ | | | 2927 | 3070 | 3196 | 3316 | 3433 | 3666 |
| | $s_g$ | 5.973 | $s$ | | | 6.212 | 6.451 | 6.646 | 6.818 | 6.975 | 7.258 |
| | $v_g$ | 0.0324 | $v$ | | | 0.0362 | 0.0422 | 0.0473 | 0.0521 | 0.0566 | 0.0652 |
| 60 | $u_g$ | 2590 | $u$ | | | 2670 | 2792 | 2893 | 2988 | 3081 | 3266 |
| (275.6) | $h_g$ | 2784 | $h$ | | | 2887 | 3045 | 3177 | 3301 | 3421 | 3657 |
| | $s_g$ | 5.890 | $s$ | | | 6.071 | 6.336 | 6.541 | 6.719 | 6.879 | 7.166 |
| | $v_g$ | 0.0274 | $v$ | | | 0.0295 | 0.0352 | 0.0399 | 0.0441 | 0.0481 | 0.0556 |
| 70 | $u_g$ | 2581 | $u$ | | | 2634 | 2772 | 2879 | 2978 | 3073 | 3260 |
| (285.8) | $h_g$ | 2772 | $h$ | | | 2841 | 3018 | 3158 | 3287 | 3410 | 3649 |
| | $s_g$ | 5.814 | $s$ | | | 5.934 | 6.231 | 6.448 | 6.632 | 6.796 | 7.088 |

## Superheated Steam

| $p$/[bar] ($t_s$/[°C]) | | | $\frac{t}{[°C]}$ | 350 | 375 | 400 | 425 | 450 | 500 | 600 | 700 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | $v_g$ | 0.02352 | $v \times 10^2$ | 2.994 | 3.220 | 3.428 | 3.625 | 3.812 | 4.170 | 4.839 | 5.476 |
| (295.0) | $h_g$ | 2758 | $h$ | 2990 | 3067 | 3139 | 3207 | 3272 | 3398 | 3641 | 3881 |
| | $s_g$ | 5.744 | $s$ | 6.133 | 6.255 | 6.364 | 6.463 | 6.555 | 6.723 | 7.019 | 7.279 |
| 90 | $v_g$ | 0.02048 | $v \times 10^2$ | 2.578 | 2.794 | 2.991 | 3.173 | 3.346 | 3.673 | 4.279 | 4.852 |
| (303.3) | $h_g$ | 2743 | $h$ | 2959 | 3042 | 3118 | 3189 | 3256 | 3385 | 3633 | 3874 |
| | $s_g$ | 5.679 | $s$ | 6.039 | 6.171 | 6.286 | 6.390 | 6.484 | 6.657 | 6.958 | 7.220 |
| 100 | $v_g$ | 0.01802 | $v \times 10^2$ | 2.241 | 2.453 | 2.639 | 2.812 | 2.972 | 3.275 | 3.831 | 4.353 |
| (311.0) | $h_g$ | 2725 | $h$ | 2926 | 3017 | 3097 | 3172 | 3241 | 3373 | 3624 | 3868 |
| | $s_g$ | 5.615 | $s$ | 5.947 | 6.091 | 6.213 | 6.321 | 6.419 | 6.596 | 6.902 | 7.166 |
| 110 | $v_g$ | 0.01598 | $v \times 10^2$ | 1.960 | 2.169 | 2.350 | 2.514 | 2.666 | 2.949 | 3.465 | 3.945 |
| (318.0) | $h_g$ | 2705 | $h$ | 2889 | 2989 | 3075 | 3153 | 3225 | 3360 | 3616 | 3862 |
| | $s_g$ | 5.553 | $s$ | 5.856 | 6.014 | 6.143 | 6.257 | 6.358 | 6.539 | 6.850 | 7.117 |
| 120 | $v_g$ | 0.01426 | $v \times 10^2$ | 1.719 | 1.931 | 2.107 | 2.265 | 2.410 | 2.677 | 3.159 | 3.605 |
| (324.6) | $h_g$ | 2685 | $h$ | 2849 | 2960 | 3052 | 3134 | 3209 | 3348 | 3607 | 3856 |
| | $s_g$ | 5.493 | $s$ | 5.762 | 5.937 | 6.076 | 6.195 | 6.301 | 6.487 | 6.802 | 7.072 |
| 130 | $v_g$ | 0.01278 | $v \times 10^2$ | 1.509 | 1.726 | 1.901 | 2.053 | 2.193 | 2.447 | 2.901 | 3.318 |
| (330.8) | $h_g$ | 2662 | $h$ | 2804 | 2929 | 3028 | 3114 | 3192 | 3335 | 3599 | 3850 |
| | $s_g$ | 5.433 | $s$ | 5.664 | 5.862 | 6.011 | 6.136 | 6.246 | 6.437 | 6.758 | 7.030 |
| 140 | $v_g$ | 0.01149 | $v \times 10^2$ | 1.321 | 1.548 | 1.722 | 1.872 | 2.006 | 2.250 | 2.679 | 3.071 |
| (336.6) | $h_g$ | 2638 | $h$ | 2753 | 2896 | 3003 | 3093 | 3175 | 3322 | 3590 | 3843 |
| | $s_g$ | 5.373 | $s$ | 5.559 | 5.784 | 5.946 | 6.079 | 6.193 | 6.390 | 6.716 | 6.991 |
| 150 | $v_g$ | 0.01035 | $v \times 10^2$ | 1.146 | 1.391 | 1.566 | 1.714 | 1.844 | 2.078 | 2.487 | 2.857 |
| (342.1) | $h_g$ | 2611 | $h$ | 2693 | 2861 | 2977 | 3073 | 3157 | 3309 | 3581 | 3837 |
| | $s_g$ | 5.312 | $s$ | 5.443 | 5.707 | 5.883 | 6.023 | 6.142 | 6.345 | 6.677 | 6.954 |
| 160 | $v_g$ | 0.00932 | $v \times 10^2$ | 0.976 | 1.248 | 1.427 | 1.573 | 1.702 | 1.928 | 2.319 | 2.670 |
| (347.3) | $h_g$ | 2582 | $h$ | 2617 | 2821 | 2949 | 3051 | 3139 | 3295 | 3573 | 3831 |
| | $s_g$ | 5.248 | $s$ | 5.304 | 5.626 | 5.820 | 5.968 | 6.093 | 6.301 | 6.639 | 6.919 |
| 170 | $v_g$ | 0.00838 | $v \times 10^2$ | | 1.117 | 1.303 | 1.449 | 1.576 | 1.796 | 2.171 | 2.506 |
| (352.3) | $h_g$ | 2548 | $h$ | | 2778 | 2920 | 3028 | 3121 | 3281 | 3564 | 3825 |
| | $s_g$ | 5.181 | $s$ | | 5.541 | 5.756 | 5.914 | 6.044 | 6.260 | 6.603 | 6.886 |
| 180 | $v_g$ | 0.00751 | $v \times 10^2$ | | 0.997 | 1.191 | 1.338 | 1.463 | 1.678 | 2.039 | 2.359 |
| (357.0) | $h_g$ | 2510 | $h$ | | 2729 | 2888 | 3004 | 3102 | 3268 | 3555 | 3818 |
| | $s_g$ | 5.108 | $s$ | | 5.449 | 5.691 | 5.861 | 5.997 | 6.219 | 6.569 | 6.855 |
| 190 | $v_g$ | 0.00668 | $v \times 10^2$ | | 0.882 | 1.089 | 1.238 | 1.362 | 1.572 | 1.921 | 2.228 |
| (361.4) | $h_g$ | 2466 | $h$ | | 2674 | 2855 | 2980 | 3082 | 3254 | 3546 | 3812 |
| | $s_g$ | 5.027 | $s$ | | 5.348 | 5.625 | 5.807 | 5.950 | 6.180 | 6.536 | 6.825 |
| 200 | $v_g$ | 0.00585 | $v \times 10^2$ | | 0.768 | 0.995 | 1.147 | 1.270 | 1.477 | 1.815 | 2.110 |
| (365.7) | $h_g$ | 2411 | $h$ | | 2605 | 2819 | 2955 | 3062 | 3239 | 3537 | 3806 |
| | $s_g$ | 4.928 | $s$ | | 5.228 | 5.556 | 5.753 | 5.904 | 6.142 | 6.505 | 6.796 |
| 210 | $v_g$ | 0.00498 | $v \times 10^2$ | | 0.650 | 0.908 | 1.064 | 1.187 | 1.390 | 1.719 | 2.003 |
| (369.8) | $h_g$ | 2336 | $h$ | | 2500 | 2781 | 2928 | 3041 | 3225 | 3528 | 3799 |
| | $s_g$ | 4.803 | $s$ | | 5.050 | 5.484 | 5.699 | 5.859 | 6.105 | 6.474 | 6.768 |
| 220 | $v_g$ | 0.00368 | $v \times 10^2$ | | 0.450 | 0.825 | 0.987 | 1.111 | 1.312 | 1.632 | 1.906 |
| (373.7) | $h_g$ | 2178 | $h$ | | 2300 | 2738 | 2900 | 3020 | 3210 | 3519 | 3793 |
| | $s_g$ | 4.552 | $s$ | | 4.725 | 5.409 | 5.645 | 5.813 | 6.068 | 6.444 | 6.742 |
| 221.2 | $v_c$ | 0.00317 | $v \times 10^2$ | 0.163 | 0.351 | 0.816 | 0.978 | 1.103 | 1.303 | 1.622 | 1.895 |
| (374.15) | $h_c$ | 2084 | $h$ | 1637 | 2139 | 2733 | 2896 | 3017 | 3208 | 3518 | 3792 |
| | $s_c$ | 4.406 | $s$ | 3.708 | 4.490 | 5.398 | 5.638 | 5.807 | 6.064 | 6.441 | 6.739 |

Linear interpolation is not accurate near the critical point.

| $p$ [bar] | $t$ [°C] | 350 | 375 | 400 | 425 | 450 | 500 | 600 | 700 | 800 |
|---|---|---|---|---|---|---|---|---|---|---|
| 225 | $v \times 10^2$ | 0.163 | 0.249 | 0.786 | 0.951 | 1.076 | 1.275 | 1.591 | 1.861 | 2.109 |
| | $h$ | 1635 | 1980 | 2716 | 2885 | 3009 | 3203 | 3514 | 3790 | 4055 |
| | $s$ | 3.704 | 4.470 | 5.369 | 5.616 | 5.790 | 6.050 | 6.430 | 6.729 | 6.988 |
| 250 | $v \times 10^2$ | 0.160 | 0.198 | 0.601 | 0.789 | 0.917 | 1.113 | 1.412 | 1.662 | 1.890 |
| | $h$ | 1625 | 1850 | 2580 | 2807 | 2951 | 3165 | 3491 | 3774 | 4043 |
| | $s$ | 3.682 | 4.026 | 5.142 | 5.474 | 5.677 | 5.962 | 6.361 | 6.667 | 6.931 |
| 275 | $v \times 10^2$ | 0.158 | 0.187 | 0.419 | 0.650 | 0.786 | 0.980 | 1.265 | 1.500 | 1.710 |
| | $h$ | 1617 | 1814 | 2382 | 2718 | 2890 | 3125 | 3468 | 3758 | 4032 |
| | $s$ | 3.662 | 3.985 | 4.828 | 5.320 | 5.562 | 5.878 | 6.296 | 6.610 | 6.878 |
| 300 | $v \times 10^2$ | 0.155 | 0.180 | 0.282 | 0.530 | 0.674 | 0.868 | 1.143 | 1.364 | 1.561 |
| | $h$ | 1610 | 1791 | 2157 | 2614 | 2823 | 3084 | 3445 | 3742 | 4020 |
| | $s$ | 3.645 | 3.933 | 4.482 | 5.157 | 5.444 | 5.795 | 6.234 | 6.557 | 6.829 |
| 350 | $v \times 10^2$ | 0.152 | 0.171 | 0.211 | 0.343 | 0.496 | 0.693 | 0.952 | 1.152 | 1.327 |
| | $h$ | 1599 | 1762 | 1992 | 2375 | 2673 | 2998 | 3397 | 3709 | 3997 |
| | $s$ | 3.614 | 3.875 | 4.219 | 4.776 | 5.197 | 5.633 | 6.120 | 6.459 | 6.741 |
| 400 | $v \times 10^2$ | 0.149 | 0.164 | 0.191 | 0.255 | 0.369 | 0.562 | 0.809 | 0.993 | 1.152 |
| | $h$ | 1590 | 1743 | 1935 | 2203 | 2514 | 2906 | 3348 | 3677 | 3974 |
| | $s$ | 3.588 | 3.832 | 4.119 | 4.510 | 4.947 | 5.474 | 6.014 | 6.371 | 6.662 |
| 450 | $v \times 10^2$ | 0.146 | 0.160 | 0.181 | 0.219 | 0.291 | 0.463 | 0.698 | 0.870 | 1.016 |
| | $h$ | 1583 | 1729 | 1901 | 2115 | 2380 | 2813 | 3299 | 3644 | 3951 |
| | $s$ | 3.565 | 3.797 | 4.056 | 4.368 | 4.740 | 5.320 | 5.914 | 6.290 | 6.590 |
| 500 | $v \times 10^2$ | 0.144 | 0.156 | 0.173 | 0.201 | 0.249 | 0.388 | 0.611 | 0.772 | 0.908 |
| | $h$ | 1577 | 1717 | 1879 | 2064 | 2288 | 2722 | 3249 | 3612 | 3928 |
| | $s$ | 3.544 | 3.768 | 4.009 | 4.279 | 4.594 | 5.176 | 5.821 | 6.214 | 6.524 |
| 550 | $v \times 10^2$ | 0.143 | 0.153 | 0.168 | 0.190 | 0.224 | 0.334 | 0.540 | 0.693 | 0.820 |
| | $h$ | 1572 | 1709 | 1862 | 2030 | 2227 | 2641 | 3200 | 3579 | 3905 |
| | $s$ | 3.525 | 3.742 | 3.971 | 4.218 | 4.494 | 5.047 | 5.731 | 6.144 | 6.462 |
| 600 | $v \times 10^2$ | 0.141 | 0.151 | 0.164 | 0.182 | 0.209 | 0.295 | 0.483 | 0.627 | 0.747 |
| | $h$ | 1568 | 1702 | 1848 | 2005 | 2184 | 2571 | 3152 | 3548 | 3883 |
| | $s$ | 3.506 | 3.718 | 3.939 | 4.168 | 4.419 | 4.937 | 5.648 | 6.077 | 6.405 |
| 650 | $v \times 10^2$ | 0.139 | 0.148 | 0.160 | 0.176 | 0.198 | 0.267 | 0.436 | 0.572 | 0.685 |
| | $h$ | 1565 | 1696 | 1837 | 1986 | 2151 | 2514 | 3106 | 3517 | 3860 |
| | $s$ | 3.489 | 3.697 | 3.910 | 4.128 | 4.360 | 4.845 | 5.568 | 6.014 | 6.352 |
| 700 | $v \times 10^2$ | 0.138 | 0.146 | 0.157 | 0.171 | 0.189 | 0.247 | 0.397 | 0.526 | 0.633 |
| | $h$ | 1561 | 1691 | 1829 | 1971 | 2127 | 2468 | 3062 | 3486 | 3839 |
| | $s$ | 3.473 | 3.678 | 3.886 | 4.093 | 4.312 | 4.769 | 5.494 | 5.955 | 6.300 |
| 750 | $v \times 10^2$ | 0.137 | 0.145 | 0.154 | 0.167 | 0.183 | 0.231 | 0.365 | 0.486 | 0.587 |
| | $h$ | 1559 | 1687 | 1821 | 1958 | 2107 | 2431 | 3021 | 3456 | 3817 |
| | $s$ | 3.459 | 3.659 | 3.863 | 4.064 | 4.272 | 4.705 | 5.425 | 5.899 | 6.252 |
| 800 | $v \times 10^2$ | 0.136 | 0.143 | 0.152 | 0.163 | 0.178 | 0.219 | 0.338 | 0.452 | 0.548 |
| | $h$ | 1557 | 1684 | 1815 | 1948 | 2091 | 2400 | 2983 | 3428 | 3797 |
| | $s$ | 3.444 | 3.642 | 3.842 | 4.037 | 4.237 | 4.651 | 5.361 | 5.845 | 6.206 |
| 900 | $v \times 10^2$ | 0.133 | 0.140 | 0.148 | 0.158 | 0.169 | 0.202 | 0.296 | 0.396 | 0.484 |
| | $h$ | 1554 | 1678 | 1805 | 1932 | 2066 | 2353 | 2916 | 3373 | 3756 |
| | $s$ | 3.418 | 3.612 | 3.805 | 3.991 | 4.179 | 4.563 | 5.248 | 5.746 | 6.120 |
| 1000 | $v \times 10^2$ | 0.131 | 0.138 | 0.145 | 0.153 | 0.163 | 0.189 | 0.267 | 0.354 | 0.434 |
| | $h$ | 1552 | 1674 | 1798 | 1920 | 2048 | 2319 | 2860 | 3324 | 3718 |
| | $s$ | 3.394 | 3.584 | 3.773 | 3.951 | 4.131 | 4.493 | 5.153 | 5.656 | 6.042 |

## Saturated Water and Steam

| $t$ [°C] | $p_s$ [bar] | $v_f$ $10^{-2}$[m³/kg] | $c_{pf}$ [kJ/kg K] | $c_{pg}$ | $\mu_f$ $10^{-6}$[kg/m s] | $\mu_g$ | $k_f$ $10^{-6}$[kW/m K] | $k_g$ | $(Pr)_f$ | $(Pr)_g$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.01 | 0.006112 | 0.10002 | 4.210 | 1.86 | 1752 | 8.49 | 569 | 16.3 | 12.96 | 0.97 |
| 5 | 0.008719 | 0.10001 | 4.204 | 1.86 | 1501 | 8.66 | 578 | 16.7 | 10.92 | 0.96 |
| 10 | 0.01227 | 0.10003 | 4.193 | 1.86 | 1300 | 8.83 | 587 | 17.1 | 9.29 | 0.96 |
| 15 | 0.01704 | 0.10010 | 4.186 | 1.87 | 1136 | 9.00 | 595 | 17.5 | 7.99 | 0.96 |
| 20 | 0.02337 | 0.10018 | 4.183 | 1.87 | 1002 | 9.18 | 603 | 17.9 | 6.95 | 0.96 |
| 25 | 0.03166 | 0.10030 | 4.181 | 1.88 | 890 | 9.35 | 611 | 18.3 | 6.09 | 0.96 |
| 30 | 0.04242 | 0.10044 | 4.179 | 1.88 | 797 | 9.52 | 618 | 18.7 | 5.39 | 0.96 |
| 35 | 0.05622 | 0.10060 | 4.178 | 1.88 | 718 | 9.70 | 625 | 19.1 | 4.80 | 0.96 |
| 40 | 0.07375 | 0.10079 | 4.179 | 1.89 | 651 | 9.87 | 632 | 19.5 | 4.30 | 0.96 |
| 45 | 0.09582 | 0.10099 | 4.181 | 1.89 | 594 | 10.0 | 638 | 19.9 | 3.89 | 0.95 |
| 50 | 0.1233 | 0.1012 | 4.182 | 1.90 | 544 | 10.2 | 643 | 20.4 | 3.54 | 0.95 |
| 55 | 0.1574 | 0.1015 | 4.183 | 1.90 | 501 | 10.4 | 648 | 20.8 | 3.23 | 0.95 |
| 60 | 0.1992 | 0.1017 | 4.185 | 1.91 | 463 | 10.6 | 653 | 21.2 | 2.97 | 0.95 |
| 65 | 0.2501 | 0.1020 | 4.188 | 1.92 | 430 | 10.7 | 658 | 21.6 | 2.74 | 0.95 |
| 70 | 0.3116 | 0.1023 | 4.191 | 1.93 | 400 | 10.9 | 662 | 22.0 | 2.53 | 0.96 |
| 75 | 0.3855 | 0.1026 | 4.194 | 1.94 | 374 | 11.1 | 666 | 22.5 | 2.36 | 0.96 |
| 80 | 0.4736 | 0.1029 | 4.198 | 1.95 | 351 | 11.3 | 670 | 22.9 | 2.20 | 0.96 |
| 85 | 0.5780 | 0.1032 | 4.203 | 1.96 | 330 | 11.4 | 673 | 23.3 | 2.06 | 0.96 |
| 90 | 0.7011 | 0.1036 | 4.208 | 1.97 | 311 | 11.6 | 676 | 23.8 | 1.94 | 0.96 |
| 95 | 0.8453 | 0.1040 | 4.213 | 1.99 | 294 | 11.8 | 678 | 24.3 | 1.83 | 0.97 |
| 100 | 1.01325 | 0.1044 | 4.219 | 2.01 | 279 | 12.0 | 681 | 24.8 | 1.73 | 0.97 |
| 105 | 1.208 | 0.1048 | 4.226 | 2.03 | 265 | 12.2 | 683 | 25.3 | 1.64 | 0.98 |
| 110 | 1.433 | 0.1052 | 4.233 | 2.05 | 252 | 12.4 | 684 | 25.8 | 1.56 | 0.99 |
| 115 | 1.691 | 0.1056 | 4.240 | 2.07 | 241 | 12.6 | 686 | 26.3 | 1.49 | 0.99 |
| 120 | 1.985 | 0.1060 | 4.248 | 2.09 | 230 | 12.8 | 687 | 26.8 | 1.42 | 1.00 |
| 125 | 2.321 | 0.1065 | 4.26 | 2.12 | 220 | 13.0 | 687 | 27.3 | 1.36 | 1.01 |
| 130 | 2.701 | 0.1070 | 4.27 | 2.15 | 211 | 13.2 | 688 | 27.8 | 1.31 | 1.02 |
| 135 | 3.131 | 0.1075 | 4.28 | 2.18 | 203 | 13.4 | 688 | 28.3 | 1.26 | 1.03 |
| 140 | 3.614 | 0.1080 | 4.29 | 2.21 | 195 | 13.5 | 688 | 28.8 | 1.22 | 1.04 |
| 145 | 4.155 | 0.1085 | 4.30 | 2.25 | 188 | 13.7 | 687 | 29.4 | 1.18 | 1.05 |
| 150 | 4.760 | 0.1091 | 4.32 | 2.29 | 181 | 13.9 | 687 | 30.0 | 1.14 | 1.07 |
| 160 | 6.181 | 0.1102 | 4.35 | 2.38 | 169 | 14.2 | 684 | 31.3 | 1.07 | 1.09 |
| 170 | 7.920 | 0.1114 | 4.38 | 2.49 | 159 | 14.6 | 681 | 32.6 | 1.02 | 1.12 |
| 180 | 10.03 | 0.1128 | 4.42 | 2.62 | 149 | 15.0 | 676 | 34.1 | 0.97 | 1.15 |
| 190 | 12.55 | 0.1142 | 4.46 | 2.76 | 141 | 15.3 | 671 | 35.7 | 0.94 | 1.18 |
| 200 | 15.55 | 0.1157 | 4.51 | 2.91 | 134 | 15.7 | 665 | 37.5 | 0.91 | 1.22 |
| 210 | 19.08 | 0.1173 | 4.56 | 3.07 | 127 | 16.0 | 657 | 39.4 | 0.88 | 1.25 |
| 220 | 23.20 | 0.1190 | 4.63 | 3.25 | 121 | 16.3 | 648 | 41.5 | 0.86 | 1.28 |
| 230 | 27.98 | 0.1209 | 4.70 | 3.45 | 116 | 16.7 | 639 | 43.9 | 0.85 | 1.31 |
| 240 | 33.48 | 0.1229 | 4.78 | 3.68 | 111 | 17.1 | 628 | 46.5 | 0.84 | 1.35 |
| 250 | 39.78 | 0.1251 | 4.87 | 3.94 | 107 | 17.5 | 616 | 49.5 | 0.85 | 1.39 |
| 260 | 46.94 | 0.1276 | 4.98 | 4.22 | 103 | 17.9 | 603 | 52.8 | 0.85 | 1.43 |
| 270 | 55.05 | 0.1302 | 5.10 | 4.55 | 99 | 18.3 | 589 | 56.6 | 0.86 | 1.47 |
| 280 | 64.19 | 0.1332 | 5.24 | 4.98 | 96 | 18.8 | 574 | 61.0 | 0.88 | 1.53 |
| 290 | 74.45 | 0.1366 | 5.42 | 5.46 | 93 | 19.3 | 558 | 66.0 | 0.90 | 1.60 |
| 300 | 85.92 | 0.1404 | 5.65 | 6.18 | 90 | 19.8 | 541 | 72.0 | 0.94 | 1.70 |
| 320 | 112.9 | 0.1499 | | | | | | | | |
| 340 | 146.1 | 0.1639 | | | | | | | | |
| 360 | 186.7 | 0.1894 | | | | | | | | |
| 370 | 210.5 | 0.2225 | | | | | | | | |
| 374.15 | 221.2 | 0.317 | | | | | | | | |

The values for saturated water can be used with good accuracy above saturation pressure. The values for saturated steam can be used with only moderate accuracy below saturation pressure at temperatures greater than 200 °C.

## General Information for $H_2O$

*Triple point:* Thermodynamic temperature (by definition) =
273.16 K ≙ 0.01 °C ≙ 491.688 R ≙ 32.018 °F
(hence 0 °C ≙ 273.15 K, 0 °F ≙ 459.67 R, 32 °F ≙ 491.67 R)
*Gas constant:* $R = R_0/M = 8.3144/18.015 = 0.4615$ kJ/kg K

## Compressed Water

| | $t$/[°C] | 0.01 | 100 | 200 | 250 | 300 | 350 | 374.15 |
|---|---|---|---|---|---|---|---|---|
| $p$/[bar] | $p_s$ | 0.006112 | 1.01325 | 15.55 | 39.78 | 85.92 | 165.4 | 221.2 |
| | $v_f \times 10^2$ | 0.1000 | 0.1044 | 0.1157 | 0.1251 | 0.1404 | 0.1741 | 0.317 |
| ($t_s$/[°C]) | $h_f$ | 0 | 419 | 852 | 1086 | 1345 | 1671 | 2084 |
| | $s_f$ | 0 | 1.307 | 2.331 | 2.793 | 3.255 | 3.779 | 4.430 |
| 100 | $(v-v_f) \times 10^2$ | −0.0005 | −0.0006 | −0.0009 | −0.0011 | −0.0007 | | |
| (311.0) | $(h-h_f)$ | +10 | +7 | +4 | 0 | −2 | | |
| | $(s-s_f)$ | 0.000 | −0.008 | −0.013 | −0.014 | −0.007 | | |
| 221.2 | $(v-v_f) \times 10^2$ | −0.0011 | −0.0012 | −0.0020 | −0.0029 | −0.0051 | −0.0107 | 0 |
| (374.15) | $(h-h_f)$ | +22 | +17 | +9 | +1 | −12 | −34 | 0 |
| | $(s-s_f)$ | +0.001 | −0.017 | −0.031 | −0.040 | −0.053 | −0.071 | 0 |
| | $(v-v_f) \times 10^2$ | −0.0023 | −0.0024 | −0.0042 | −0.0064 | −0.0117 | −0.0298 | −0.161 |
| 500 | $(h-h_f)$ | +49 | +38 | +23 | +8 | −21 | −94 | −369 |
| | $(s-s_f)$ | 0.000 | −0.037 | −0.068 | −0.091 | −0.134 | −0.235 | −0.670 |
| | $(v-v_f) \times 10^2$ | −0.0044 | −0.0044 | −0.0075 | −0.0111 | −0.0191 | −0.0427 | −0.180 |
| 1000 | $(h-h_f)$ | +96 | +76 | +51 | +28 | −17 | −119 | −415 |
| | $(s-s_f)$ | −0.007 | −0.070 | −0.124 | −0.164 | −0.235 | −0.385 | −0.853 |

## Saturated Ice and Steam

| $t$ | $p_s$ | $v_i$ | $v_g$ | $u_i$ | $u_g$ | $h_i$ | $h_g$ | $s_i$ | $s_g$ |
|---|---|---|---|---|---|---|---|---|---|
| [°C] | [bar] | $10^{-2}$[m³/kg] | [m³/kg] | [kJ/kg] | | [kJ/kg] | | [kJ/kg K] | |
| 0.01 | 0.006112 | 0.1091 | 206.1 | −333.5 | 2374.7 | −333.5 | 2500.8 | −1.221 | 9.155 |
| −10 | 0.002598 | 0.1089 | 467.5 | −354.2 | 2360.8 | −354.2 | 2482.2 | −1.298 | 9.481 |
| −20 | 0.001038 | 0.1087 | 1125 | −374.1 | 2346.8 | −374.1 | 2463.6 | −1.375 | 9.835 |
| −30 | 0.0003809 | 0.1086 | 2946 | −393.3 | 2332.9 | −393.3 | 2445.1 | −1.452 | 10.221 |
| −40 | 0.0001288 | 0.1084 | 8354 | −411.8 | 2319.0 | −411.8 | 2426.6 | −1.530 | 10.644 |

## Isentropic Expansion of Steam—Approximate Relations

*Wet equilibrium expansion:*

$pv^n$ = constant, with $n \approx 1.135$ for steam initially dry saturated

*Superheated and supersaturated expansion:*

$pv^n$ = constant and $p/T^{n/(n-1)}$ = constant, with $n \approx 1.3$

$$\text{Enthalpy drop } \frac{(h_2-h_1)}{[\text{kJ/kg}]} = \left(\frac{h_1}{[\text{kJ/kg}]} - 1943\right)\left[\left(\frac{p_2}{p_1}\right)^{(n-1)/n} - 1\right]$$

*Specific volume of supersaturated steam:*

$$\frac{p}{[\text{bar}]} \times \frac{v}{[\text{m}^3/\text{kg}]} \times 10^2 = \frac{0.3}{1.3}\left(\frac{h}{[\text{kJ/kg}]} - 1943\right)$$

## Ammonia – $NH_3$ (Refrigerant 717)

| | Saturation Values | | | | | | Superheat $(t-t_s)$ 50 K | | 100 K | |
|---|---|---|---|---|---|---|---|---|---|---|
| $t$ | $p_s$ | $v_g$ | $h_f$ | $h_g$ | $s_f$ | $s_g$ | $h$ | $s$ | $h$ | $s$ |
| [°C] | [bar] | [m³/kg] | [kJ/kg] | | [kJ/kg K] | | [kJ/kg] | [kJ/kg K] | [kJ/kg] | [kJ/kg K] |
| −50 | 0.4089 | 2.625 | −44.4 | 1373.3 | −0.194 | 6.159 | 1479.8 | 6.592 | 1585.9 | 6.948 |
| −45 | 0.5454 | 2.005 | −22.3 | 1381.6 | −0.096 | 6.057 | 1489.3 | 6.486 | 1596.1 | 6.839 |
| −40 | 0.7177 | 1.552 | 0 | 1390.0 | 0 | 5.962 | 1498.6 | 6.387 | 1606.3 | 6.736 |
| −35 | 0.9322 | 1.216 | 22.3 | 1397.9 | 0.095 | 5.872 | 1507.9 | 6.293 | 1616.3 | 6.639 |
| −30 | 1.196 | 0.9633 | 44.7 | 1405.6 | 0.188 | 5.785 | 1517.0 | 6.203 | 1626.3 | 6.547 |
| −28 | 1.317 | 0.8809 | 53.6 | 1408.5 | 0.224 | 5.751 | 1520.7 | 6.169 | 1630.3 | 6.512 |
| −26 | 1.447 | 0.8058 | 62.6 | 1411.4 | 0.261 | 5.718 | 1524.3 | 6.135 | 1634.2 | 6.477 |
| −24 | 1.588 | 0.7389 | 71.7 | 1414.3 | 0.297 | 5.686 | 1527.9 | 6.103 | 1638.2 | 6.444 |
| −22 | 1.740 | 0.6783 | 80.8 | 1417.3 | 0.333 | 5.655 | 1531.4 | 6.071 | 1642.2 | 6.411 |
| −20 | 1.902 | 0.6237 | 89.8 | 1420.0 | 0.368 | 5.623 | 1534.8 | 6.039 | 1646.0 | 6.379 |
| −18 | 2.077 | 0.5743 | 98.8 | 1422.7 | 0.404 | 5.593 | 1538.2 | 6.008 | 1650.0 | 6.347 |
| −16 | 2.265 | 0.5296 | 107.9 | 1425.3 | 0.440 | 5.563 | 1541.7 | 5.978 | 1653.8 | 6.316 |
| −14 | 2.465 | 0.4890 | 117.0 | 1427.9 | 0.475 | 5.533 | 1545.1 | 5.948 | 1657.7 | 6.286 |
| −12 | 2.680 | 0.4521 | 126.2 | 1430.5 | 0.510 | 5.504 | 1548.5 | 5.919 | 1661.5 | 6.256 |
| −10 | 2.908 | 0.4185 | 135.4 | 1433.0 | 0.544 | 5.475 | 1551.7 | 5.891 | 1665.3 | 6.227 |
| − 8 | 3.153 | 0.3879 | 144.5 | 1435.3 | 0.579 | 5.447 | 1554.9 | 5.863 | 1669.0 | 6.199 |
| − 6 | 3.413 | 0.3599 | 153.6 | 1437.6 | 0.613 | 5.419 | 1558.2 | 5.836 | 1672.8 | 6.171 |
| − 4 | 3.691 | 0.3344 | 162.8 | 1439.9 | 0.647 | 5.392 | 1561.4 | 5.808 | 1676.4 | 6.143 |
| − 2 | 3.983 | 0.3110 | 172.0 | 1442.2 | 0.681 | 5.365 | 1564.6 | 5.782 | 1680.1 | 6.116 |
| 0 | 4.295 | 0.2895 | 181.2 | 1444.4 | 0.715 | 5.340 | 1567.8 | 5.756 | 1683.9 | 6.090 |
| 2 | 4.625 | 0.2699 | 190.4 | 1446.5 | 0.749 | 5.314 | 1570.9 | 5.731 | 1687.5 | 6.065 |
| 4 | 4.975 | 0.2517 | 199.7 | 1448.5 | 0.782 | 5.288 | 1574.0 | 5.706 | 1691.2 | 6.040 |
| 6 | 5.346 | 0.2351 | 209.1 | 1450.6 | 0.816 | 5.263 | 1577.0 | 5.682 | 1694.9 | 6.015 |
| 8 | 5.736 | 0.2198 | 218.5 | 1452.5 | 0.849 | 5.238 | 1580.1 | 5.658 | 1698.4 | 5.991 |
| 10 | 6.149 | 0.2056 | 227.8 | 1454.3 | 0.881 | 5.213 | 1583.1 | 5.634 | 1702.2 | 5.967 |
| 12 | 6.585 | 0.1926 | 237.2 | 1456.1 | 0.914 | 5.189 | 1586.0 | 5.611 | 1705.7 | 5.943 |
| 14 | 7.045 | 0.1805 | 246.6 | 1457.8 | 0.947 | 5.165 | 1588.9 | 5.588 | 1709.1 | 5.920 |
| 16 | 7.529 | 0.1693 | 256.0 | 1459.5 | 0.979 | 5.141 | 1591.7 | 5.565 | 1712.5 | 5.898 |
| 18 | 8.035 | 0.1590 | 265.5 | 1461.1 | 1.012 | 5.118 | 1594.4 | 5.543 | 1715.9 | 5.876 |
| 20 | 8.570 | 0.1494 | 275.1 | 1462.6 | 1.044 | 5.095 | 1597.2 | 5.521 | 1719.3 | 5.854 |
| 22 | 9.134 | 0.1405 | 284.6 | 1463.9 | 1.076 | 5.072 | 1600.0 | 5.499 | 1722.8 | 5.832 |
| 24 | 9.722 | 0.1322 | 294.1 | 1465.2 | 1.108 | 5.049 | 1602.7 | 5.478 | 1726.3 | 5.811 |
| 26 | 10.34 | 0.1245 | 303.7 | 1466.5 | 1.140 | 5.027 | 1605.3 | 5.458 | 1729.6 | 5.790 |
| 28 | 10.99 | 0.1173 | 313.4 | 1467.8 | 1.172 | 5.005 | 1608.0 | 5.437 | 1732.7 | 5.770 |
| 30 | 11.67 | 0.1106 | 323.1 | 1468.9 | 1.204 | 4.984 | 1610.5 | 5.417 | 1735.9 | 5.750 |
| 32 | 12.37 | 0.1044 | 332.8 | 1469.9 | 1.235 | 4.962 | 1613.0 | 5.397 | 1739.3 | 5.731 |
| 34 | 13.11 | 0.0986 | 342.5 | 1470.8 | 1.267 | 4.940 | 1615.4 | 5.378 | 1742.6 | 5.711 |
| 36 | 13.89 | 0.0931 | 352.3 | 1471.8 | 1.298 | 4.919 | 1617.8 | 5.358 | 1745.7 | 5.692 |
| 38 | 14.70 | 0.0880 | 362.1 | 1472.6 | 1.329 | 4.898 | 1620.1 | 5.340 | 1748.7 | 5.674 |
| 40 | 15.54 | 0.0833 | 371.9 | 1473.3 | 1.360 | 4.877 | 1622.4 | 5.321 | 1751.9 | 5.655 |
| 42 | 16.42 | 0.0788 | 381.8 | 1473.8 | 1.391 | 4.856 | 1624.6 | 5.302 | 1755.0 | 5.637 |
| 44 | 17.34 | 0.0746 | 391.8 | 1474.2 | 1.422 | 4.835 | 1626.8 | 5.284 | 1758.0 | 5.619 |
| 46 | 18.30 | 0.0706 | 401.8 | 1474.5 | 1.453 | 4.814 | 1629.0 | 5.266 | 1761.0 | 5.602 |
| 48 | 19.29 | 0.0670 | 411.9 | 1474.7 | 1.484 | 4.793 | 1631.1 | 5.248 | 1764.0 | 5.584 |
| 50 | 20.33 | 0.0635 | 421.9 | 1474.7 | 1.515 | 4.773 | 1633.1 | 5.230 | 1766.8 | 5.567 |

Critical point $t_c = 132.4$ °C, $p_c = 113.0$ bar.
Molar mass $M = 17.030$ kg/kmol; further properties of the liquid are given on p. 15.

## Dichlorodifluoromethane – $CF_2Cl_2$ (Refrigerant 12)

| Saturation Values | | | | | | | Superheat ($t-t_s$) 15 K | | 30 K | |
|---|---|---|---|---|---|---|---|---|---|---|
| $t$ | $p_s$ | $v_g$ | $h_f$ | $h_g$ | $s_f$ | $s_g$ | $h$ | $s$ | $h$ | $s$ |
| [°C] | [bar] | [m³/kg] | [kJ/kg] | | [kJ/kg K] | | [kJ/kg] | [kJ/kg K] | [kJ/kg] | [kJ/kg K] |
| −100 | 0.0118 | 10.100 | −51.84 | 142.00 | −0.2567 | 0.8628 | 148.89 | 0.9019 | 156.10 | 0.9428 |
| − 95 | 0.0181 | 6.585 | −47.56 | 144.22 | −0.2323 | 0.8442 | 151.23 | 0.8830 | 158.55 | 0.9195 |
| − 90 | 0.0284 | 4.416 | −43.28 | 146.46 | −0.2086 | 0.8274 | 153.59 | 0.8649 | 161.02 | 0.9010 |
| − 85 | 0.0424 | 3.037 | −39.00 | 148.73 | −0.1856 | 0.8122 | 155.98 | 0.8493 | 163.52 | 0.8851 |
| − 80 | 0.0617 | 2.138 | −34.72 | 151.02 | −0.1631 | 0.7985 | 158.39 | 0.8351 | 166.04 | 0.8706 |
| − 75 | 0.0879 | 1.538 | −30.43 | 153.32 | −0.1412 | 0.7861 | 160.82 | 0.8226 | 168.57 | 0.8578 |
| − 70 | 0.1227 | 1.127 | −26.13 | 155.63 | −0.1198 | 0.7749 | 163.26 | 0.8110 | 171.12 | 0.8459 |
| − 65 | 0.1680 | 0.8412 | −21.81 | 157.96 | −0.0988 | 0.7649 | 165.70 | 0.8008 | 173.68 | 0.8355 |
| − 60 | 0.2262 | 0.6379 | −17.49 | 160.29 | −0.0783 | 0.7558 | 168.15 | 0.7915 | 176.26 | 0.8259 |
| − 55 | 0.2998 | 0.4910 | −13.14 | 162.62 | −0.0582 | 0.7475 | 170.60 | 0.7830 | 178.84 | 0.8172 |
| − 50 | 0.3915 | 0.3831 | − 8.78 | 164.95 | −0.0384 | 0.7401 | 173.07 | 0.7753 | 181.43 | 0.8093 |
| − 45 | 0.5044 | 0.3027 | − 4.40 | 167.28 | −0.0190 | 0.7335 | 175.54 | 0.7685 | 184.01 | 0.8023 |
| − 40 | 0.6417 | 0.2419 | 0 | 169.60 | 0 | 0.7274 | 178.00 | 0.7623 | 186.60 | 0.7959 |
| − 35 | 0.8071 | 0.1954 | 4.42 | 171.90 | 0.0187 | 0.7219 | 180.45 | 0.7568 | 189.18 | 0.7902 |
| − 30 | 1.004 | 0.1594 | 8.86 | 174.20 | 0.0371 | 0.7170 | 182.90 | 0.7517 | 191.76 | 0.7851 |
| − 25 | 1.237 | 0.1312 | 13.33 | 176.48 | 0.0552 | 0.7127 | 185.33 | 0.7473 | 194.33 | 0.7805 |
| − 20 | 1.509 | 0.1088 | 17.82 | 178.73 | 0.0731 | 0.7087 | 187.75 | 0.7432 | 196.89 | 0.7764 |
| − 15 | 1.826 | 0.0910 | 22.33 | 180.97 | 0.0906 | 0.7051 | 190.15 | 0.7397 | 199.44 | 0.7728 |
| − 10 | 2.191 | 0.0766 | 26.87 | 183.19 | 0.1080 | 0.7020 | 192.53 | 0.7365 | 201.97 | 0.7695 |
| − 5 | 2.610 | 0.0650 | 31.45 | 185.38 | 0.1251 | 0.6991 | 194.90 | 0.7336 | 204.49 | 0.7666 |
| 0 | 3.086 | 0.0554 | 36.05 | 187.53 | 0.1420 | 0.6966 | 197.25 | 0.7311 | 206.99 | 0.7641 |
| 5 | 3.626 | 0.0475 | 40.69 | 189.66 | 0.1587 | 0.6943 | 199.56 | 0.7289 | 209.47 | 0.7618 |
| 10 | 4.233 | 0.0409 | 45.37 | 191.74 | 0.1752 | 0.6921 | 201.85 | 0.7268 | 211.92 | 0.7598 |
| 15 | 4.914 | 0.0354 | 50.10 | 193.78 | 0.1915 | 0.6901 | 204.10 | 0.7251 | 214.35 | 0.7580 |
| 20 | 5.673 | 0.0308 | 54.87 | 195.78 | 0.2078 | 0.6885 | 206.32 | 0.7235 | 216.75 | 0.7565 |
| 25 | 6.516 | 0.0269 | 59.70 | 197.73 | 0.2239 | 0.6869 | 208.50 | 0.7220 | 219.11 | 0.7552 |
| 30 | 7.449 | 0.0235 | 64.59 | 199.62 | 0.2399 | 0.6853 | 210.63 | 0.7208 | 221.44 | 0.7540 |
| 35 | 8.477 | 0.0206 | 69.55 | 201.45 | 0.2559 | 0.6839 | 212.72 | 0.7196 | 223.73 | 0.7529 |
| 40 | 9.607 | 0.0182 | 74.59 | 203.20 | 0.2718 | 0.6825 | 214.76 | 0.7185 | 225.98 | 0.7519 |
| 45 | 10.84 | 0.0160 | 79.71 | 204.87 | 0.2877 | 0.6811 | 216.74 | 0.7175 | 228.18 | 0.7511 |
| 50 | 12.19 | 0.0142 | 84.94 | 206.45 | 0.3037 | 0.6797 | 218.64 | 0.7166 | 230.33 | 0.7503 |
| 55 | 13.66 | 0.0125 | 90.27 | 207.92 | 0.3197 | 0.6782 | 220.48 | 0.7156 | 232.42 | 0.7496 |
| 60 | 15.26 | 0.0111 | 95.74 | 209.26 | 0.3358 | 0.6765 | 222.23 | 0.7146 | 234.45 | 0.7490 |
| 65 | 16.99 | 0.00985 | 101.36 | 210.46 | 0.3521 | 0.6747 | 223.89 | 0.7136 | 236.42 | 0.7484 |
| 70 | 18.86 | 0.00873 | 107.15 | 211.48 | 0.3686 | 0.6726 | 225.45 | 0.7125 | 238.32 | 0.7477 |
| 75 | 20.88 | 0.00772 | 113.15 | 212.29 | 0.3854 | 0.6702 | 226.89 | 0.7113 | 240.13 | 0.7470 |
| 80 | 23.05 | 0.00682 | 119.39 | 212.83 | 0.4027 | 0.6673 | 228.21 | 0.7099 | 241.86 | 0.7463 |
| 85 | 25.38 | 0.00601 | 125.93 | 213.04 | 0.4204 | 0.6636 | 229.39 | 0.7084 | 243.50 | 0.7455 |
| 90 | 27.89 | 0.00526 | 132.84 | 212.80 | 0.4389 | 0.6591 | 230.43 | 0.7067 | 245.03 | 0.7445 |
| 95 | 30.57 | 0.00456 | 140.23 | 211.94 | 0.4583 | 0.6531 | 231.30 | 0.7047 | 246.47 | 0.7435 |
| 100 | 33.44 | 0.00390 | 148.32 | 210.12 | 0.4793 | 0.6449 | 231.93 | 0.7023 | 247.80 | 0.7424 |
| 105 | 36.51 | 0.00324 | 157.52 | 206.57 | 0.5028 | 0.6325 | 232.22 | 0.6994 | 248.97 | 0.7412 |
| 110 | 39.79 | 0.00246 | 169.55 | 197.99 | 0.5334 | 0.6076 | 232.47 | 0.6964 | 250.10 | 0.7399 |
| 112 | 41.15 | 0.00179 | 183.43 | 183.43 | 0.5690 | 0.5690 | 232.80 | 0.6958 | 250.58 | 0.7394 |

Molar mass $M = 120.91$ kg/kmol; further properties of the liquid are given on p. 15.

## Mercury – Hg

| $p$ | $t_s$ | $v_g$ | $h_f$ | $h_{fg}$ | $h_g$ | $s_f$ | $s_{fg}$ | $s_g$ |
|---|---|---|---|---|---|---|---|---|
| [bar] | [°C] | [m³/kg] | | [kJ/kg] | | | [kJ/kg K] | |
| 0.0006 | 109.2 | 259.6 | 15.13 | 297.20 | 312.33 | 0.0466 | 0.7774 | 0.8240 |
| 0.0007 | 112.3 | 224.3 | 15.55 | 297.14 | 312.69 | 0.0477 | 0.7709 | 0.8186 |
| 0.0008 | 115.0 | 197.7 | 15.93 | 297.09 | 313.02 | 0.0487 | 0.7654 | 0.8141 |
| 0.0009 | 117.5 | 176.8 | 16.27 | 297.04 | 313.31 | 0.0496 | 0.7604 | 0.8100 |
| 0.0010 | 119.7 | 160.1 | 16.58 | 297.00 | 313.58 | 0.0503 | 0.7560 | 0.8063 |
| 0.002 | 134.9 | 83.18 | 18.67 | 296.71 | 315.38 | 0.0556 | 0.7271 | 0.7827 |
| 0.004 | 151.5 | 43.29 | 20.93 | 296.40 | 317.33 | 0.0610 | 0.6981 | 0.7591 |
| 0.006 | 161.8 | 29.57 | 22.33 | 296.21 | 318.54 | 0.0643 | 0.6811 | 0.7454 |
| 0.008 | 169.4 | 22.57 | 23.37 | 296.06 | 319.43 | 0.0666 | 0.6690 | 0.7356 |
| 0.010 | 175.5 | 18.31 | 24.21 | 295.95 | 320.16 | 0.0685 | 0.6596 | 0.7281 |
| 0.02 | 195.6 | 9.570 | 26.94 | 295.57 | 322.51 | 0.0744 | 0.6305 | 0.7049 |
| 0.04 | 217.7 | 5.013 | 29.92 | 295.15 | 325.07 | 0.0806 | 0.6013 | 0.6819 |
| 0.06 | 231.6 | 3.438 | 31.81 | 294.89 | 326.70 | 0.0843 | 0.5842 | 0.6685 |
| 0.08 | 242.0 | 2.632 | 33.21 | 294.70 | 327.91 | 0.0870 | 0.5721 | 0.6591 |
| 0.10 | 250.3 | 2.140 | 34.33 | 294.54 | 328.87 | 0.0892 | 0.5627 | 0.6519 |
| 0.2 | 278.1 | 1.128 | 38.05 | 294.02 | 332.07 | 0.0961 | 0.5334 | 0.6295 |
| 0.4 | 309.1 | 0.5942 | 42.21 | 293.43 | 335.64 | 0.1034 | 0.5039 | 0.6073 |
| 0.6 | 329.0 | 0.4113 | 44.85 | 293.06 | 337.91 | 0.1078 | 0.4869 | 0.5947 |
| 0.8 | 343.9 | 0.3163 | 46.84 | 292.78 | 339.62 | 0.1110 | 0.4745 | 0.5855 |
| 1 | 356.1 | 0.2581 | 48.45 | 292.55 | 341.00 | 0.1136 | 0.4649 | 0.5785 |
| 2 | 397.1 | 0.1377 | 53.87 | 291.77 | 345.64 | 0.1218 | 0.4353 | 0.5571 |
| 3 | 423.8 | 0.09551 | 57.38 | 291.27 | 348.65 | 0.1268 | 0.4179 | 0.5447 |
| 4 | 444.1 | 0.07378 | 60.03 | 290.89 | 350.92 | 0.1305 | 0.4056 | 0.5361 |
| 5 | 460.7 | 0.06044 | 62.20 | 290.58 | 352.78 | 0.1334 | 0.3960 | 0.5294 |
| 6 | 474.9 | 0.05137 | 64.06 | 290.31 | 354.37 | 0.1359 | 0.3881 | 0.5240 |
| 7 | 487.3 | 0.04479 | 65.66 | 290.08 | 355.74 | 0.1380 | 0.3815 | 0.5195 |
| 8 | 498.4 | 0.03978 | 67.11 | 289.87 | 356.98 | 0.1398 | 0.3757 | 0.5155 |
| 9 | 508.5 | 0.03584 | 68.42 | 289.68 | 358.10 | 0.1415 | 0.3706 | 0.5121 |
| 10 | 517.8 | 0.03266 | 69.61 | 289.50 | 359.11 | 0.1429 | 0.3660 | 0.5089 |
| 12 | 534.4 | 0.02781 | 71.75 | 289.19 | 360.94 | 0.1455 | 0.3581 | 0.5036 |
| 14 | 549.0 | 0.02429 | 73.63 | 288.92 | 362.55 | 0.1478 | 0.3514 | 0.4992 |
| 16 | 562.0 | 0.02161 | 75.37 | 288.67 | 364.04 | 0.1498 | 0.3456 | 0.4954 |
| 18 | 574.0 | 0.01949 | 76.83 | 288.45 | 365.28 | 0.1515 | 0.3405 | 0.4920 |
| 20 | 584.9 | 0.01778 | 78.23 | 288.24 | 366.47 | 0.1531 | 0.3359 | 0.4890 |
| 22 | 595.1 | 0.01637 | 79.54 | 288.05 | 367.59 | 0.1546 | 0.3318 | 0.4864 |
| 24 | 604.6 | 0.01518 | 80.75 | 287.87 | 368.62 | 0.1559 | 0.3280 | 0.4839 |
| 26 | 613.5 | 0.01416 | 81.89 | 287.70 | 369.59 | 0.1571 | 0.3245 | 0.4816 |
| 28 | 622.0 | 0.01329 | 82.96 | 287.54 | 370.50 | 0.1583 | 0.3212 | 0.4795 |
| 30 | 630.0 | 0.01252 | 83.97 | 287.39 | 371.36 | 0.1594 | 0.3182 | 0.4776 |
| 35 | 648.5 | 0.01096 | 86.33 | 287.04 | 373.37 | 0.1619 | 0.3115 | 0.4734 |
| 40 | 665.1 | 0.00978 | 88.43 | 286.73 | 375.16 | 0.1641 | 0.3056 | 0.4697 |
| 45 | 680.3 | 0.00885 | 90.35 | 286.44 | 376.79 | 0.1660 | 0.3004 | 0.4664 |
| 50 | 694.4 | 0.00809 | 92.11 | 286.18 | 378.29 | 0.1678 | 0.2958 | 0.4636 |
| 55 | 707.4 | 0.00746 | 93.76 | 285.93 | 379.69 | 0.1694 | 0.2916 | 0.4610 |
| 60 | 719.7 | 0.00693 | 95.30 | 285.70 | 381.00 | 0.1709 | 0.2878 | 0.4587 |
| 65 | 731.3 | 0.00648 | 96.75 | 285.48 | 382.23 | 0.1723 | 0.2842 | 0.4565 |
| 70 | 742.3 | 0.00609 | 98.12 | 285.28 | 383.40 | 0.1736 | 0.2809 | 0.4545 |
| 75 | 752.7 | 0.00575 | 99.42 | 285.08 | 384.50 | 0.1748 | 0.2779 | 0.4527 |

$h_f$ and $s_f$ are zero at 0 °C. Molar mass $M = 200.59$ kg/kmol; for superheated vapour $c_p = 0.1036$ kJ/kg K; further properties of the liquid are given on p. 15.

| | $T$/[K] | 250 | 300 | 400 | 500 | 600 | 800 | 1000 |
|---|---|---|---|---|---|---|---|---|
| Ammonia ($NH_3$) | $c_p$ | 4.52 | 4.75 | 6.91 | — | — | — | — |
| sat. liquid | ρ | 669 | 600 | 346 | — | — | — | — |
| t.p. = 195.4 K | $\mu \times 10^6$ | 245 | 141 | 38 | — | — | — | — |
| $M$ = 17.030 kg/kmol | $k \times 10^6$ | 592 | 477 | 207 | — | — | — | — |
| R–12 ($CF_2Cl_2$) | $c_p$ | 0.902 | 0.980 | — | — | — | — | — |
| sat. liquid | ρ | 1468 | 1304 | — | — | — | — | — |
| t.p. = 115.3 K | $\mu \times 10^6$ | 336 | 213 | — | — | — | — | — |
| $M$ = 120.91 kg/kmol | $k \times 10^6$ | 86.8 | 68.6 | — | — | — | — | — |
| Lead (Pb)-Bismuth | $c_p$ | — | — | 0.146 | 0.146 | 0.146 | 0.146 | 0.146 |
| (Bi) 44.5%–55.5% | ρ | — | — | 10570 | 10450 | 10330 | 10090 | 9840 |
| eutectic liquid | $\mu \times 10^6$ | — | — | 3360 | 2340 | 1840 | 1330 | 1100 |
| m.p. 397 K | $k$ | — | — | 0.0109 | 0.0120 | 0.0129 | 0.0150 | 0.0170 |
| Mercury (Hg) | $c_p$ | 0.141 | 0.139 | 0.137 | 0.137 | 0.137 | 0.138 | — |
| liquid | ρ | 13650 | 13530 | 13290 | 13050 | 12840 | 12420 | — |
| m.p. = 234.3 K | $\mu \times 10^6$ | 1880 | 1520 | 1190 | 1010 | 890 | 780 | — |
| $M$ = 200.59 kg/kmol | $k$ | 0.0075 | 0.0081 | 0.0094 | 0.0107 | 0.0128 | 0.0137 | — |
| Potassium (K) | $c_p$ | — | 0.710 | 0.805 | 0.786 | 0.772 | 0.768 | 0.775 |
| liquid | ρ | — | 860 | 812 | 789 | 766 | 721 | 675 |
| m.p. 336.8 K | $\mu \times 10^6$ | solid | solid | 417 | 319 | 258 | 179 | 133 |
| $M$ = 39.098 kg/kmol | $k$ | — | 0.099 | 0.0465 | 0.0454 | 0.0425 | 0.0337 | 0.0278 |
| Sodium (Na) | $c_p$ | 1.179 | 1.224 | 1.369 | 1.315 | 1.277 | 1.273 | 1.277 |
| liquid | ρ | 977 | 967 | 921 | 897 | 872 | 823 | 774 |
| m.p. 370.5 K | $\mu \times 10^6$ | solid | solid | 610 | 420 | 320 | 230 | 180 |
| $M$ = 22.990 kg/kmol | $k$ | 0.135 | 0.135 | 0.086 | 0.080 | 0.074 | 0.063 | 0.059 |
| Sodium-Potassium | $c_p$ | — | 0.977 | 0.929 | 0.904 | 0.886 | 0.871 | 0.882 |
| 22%–78% | ρ | — | 869 | 845 | 821 | 797 | 749 | 700 |
| eutectic liquid | $\mu \times 10^6$ | solid | 780 | 467 | 348 | 277 | 193 | 146 |
| m.p. 262 K | $k$ | — | 0.0222 | 0.0236 | 0.0249 | 0.0262 | 0.0287 | 0.0312 |
| Argon (Ar) | $c_p$ | 0,5203 | 0.5203 | 0.5203 | 0.5203 | 0.5203 | 0.5203 | 0.5203 |
| 1 atm | ρ | 1.947 | 1.623 | 1.217 | 0.974 | 0.811 | 0.609 | 0.487 |
| $M$ = 39.948 kg/kmol | $\mu \times 10^6$ | 19.74 | 22.94 | 28.67 | 33.75 | 38.38 | 46.71 | 54.21 |
| | $k \times 10^6$ | 15.15 | 17.66 | 22.27 | 26.41 | 30.16 | 36.83 | 42.66 |
| Carbon dioxide ($CO_2$) | $c_p$ | 0.791 | 0.846 | 0.939 | 1.014 | 1.075 | 1.169 | 1.234 |
| 1 atm | ρ | 2.145 | 1.788 | 1.341 | 1.073 | 0.894 | 0.670 | 0.536 |
| $M$ = 44.010 kg/kmol | $\mu \times 10^6$ | 12.60 | 14.99 | 19.46 | 23.67 | 27.32 | 33.81 | 39.51 |
| | $k \times 10^6$ | 12.90 | 16.61 | 24.75 | 32.74 | 40.40 | 54.64 | 67.52 |
| Helium (He) | $c_p$ | 5.193 | 5.193 | 5.193 | 5.193 | 5.193 | 5.193 | 5.193 |
| 1 atm | ρ | 0.1951 | 0.1626 | 0.1220 | 0.0976 | 0.0813 | 0.0610 | 0.0488 |
| $M$ = 4.003 kg/kmol | $\mu \times 10^6$ | 18.40 | 20.80 | 25.23 | 29.30 | 33.12 | 40.19 | 46.70 |
| | $k \times 10^6$ | 134.0 | 149.8 | 177.9 | 202.6 | 224.7 | — | — |
| Hydrogen ($H_2$) | $c_p$ | 14.05 | 14.31 | 14.48 | 14.51 | 14.55 | 14.69 | 14.98 |
| 1 atm | ρ | 0.0983 | 0.0819 | 0.0614 | 0.0491 | 0.0409 | 0.0307 | 0.0246 |
| $M$ = 2.016 kg/kmol | $\mu \times 10^6$ | 7.92 | 8.96 | 10.87 | 12.64 | 14.29 | 17.34 | 20.13 |
| | $k \times 10^6$ | 156.1 | 181.7 | 228.1 | 271.8 | 314.7 | 402.2 | — |
| Steam ($H_2O$) | $c_p$ | 1.855 | 1.864 | 1.901 | 1.954 | 2.015 | 2.147 | 2.288 |
| low pressures | $\mu \times 10^6$ | — | 9.42 | 13.2 | 17.3 | 21.3 | 29.5 | 37.6 |
| $M$ = 18.015 kg/kmol | $k \times 10^6$ | — | 18.8 | 26.6 | 35.7 | 46.3 | 70.8 | 97.9 |

The properties $c_p$, μ and $k$ (and ρ for liquids) do not vary much with pressure: see also footnote on p.16.

## Dry Air at Low Pressure

| $T$ [K] | $c_p$ [kJ/kg K] | $c_v$ [kJ/kg K] | $\gamma$ | $\mu$ $10^{-5}$[kg/m s] | $k$ $10^{-5}$[kW/m K] | $Pr$ | at 1 atm $\rho$ [kg/m³] | at 1 atm $\nu$ $10^{-5}$[m²/s] |
|---|---|---|---|---|---|---|---|---|
| 175 | 1.0023 | 0.7152 | 1.401 | 1.182 | 1.593 | 0.744 | 2.017 | 0.586 |
| 200 | 1.0025 | 0.7154 | 1.401 | 1.329 | 1.809 | 0.736 | 1.765 | 0.753 |
| 225 | 1.0027 | 0.7156 | 1.401 | 1.467 | 2.020 | 0.728 | 1.569 | 0.935 |
| 250 | 1.0031 | 0.7160 | 1.401 | 1.599 | 2.227 | 0.720 | 1.412 | 1.132 |
| 275 | 1.0038 | 0.7167 | 1.401 | 1.725 | 2.428 | 0.713 | 1.284 | 1.343 |
| 300 | 1.0049 | 0.7178 | 1.400 | 1.846 | 2.624 | 0.707 | 1.177 | 1.568 |
| 325 | 1.0063 | 0.7192 | 1.400 | 1.962 | 2.816 | 0.701 | 1.086 | 1.807 |
| 350 | 1.0082 | 0.7211 | 1.398 | 2.075 | 3.003 | 0.697 | 1.009 | 2.056 |
| 375 | 1.0106 | 0.7235 | 1.397 | 2.181 | 3.186 | 0.692 | 0.9413 | 2.317 |
| 400 | 1.0135 | 0.7264 | 1.395 | 2.286 | 3.365 | 0.688 | 0.8824 | 2.591 |
| 450 | 1.0206 | 0.7335 | 1.391 | 2.485 | 3.710 | 0.684 | 0.7844 | 3.168 |
| 500 | 1.0295 | 0.7424 | 1.387 | 2.670 | 4.041 | 0.680 | 0.7060 | 3.782 |
| 550 | 1.0398 | 0.7527 | 1.381 | 2.849 | 4.357 | 0.680 | 0.6418 | 4.439 |
| 600 | 1.0511 | 0.7640 | 1.376 | 3.017 | 4.661 | 0.680 | 0.5883 | 5.128 |
| 650 | 1.0629 | 0.7758 | 1.370 | 3.178 | 4.954 | 0.682 | 0.5430 | 5.853 |
| 700 | 1.0750 | 0.7879 | 1.364 | 3.332 | 5.236 | 0.684 | 0.5043 | 6.607 |
| 750 | 1.0870 | 0.7999 | 1.359 | 3.482 | 5.509 | 0.687 | 0.4706 | 7.399 |
| 800 | 1.0987 | 0.8116 | 1.354 | 3.624 | 5.774 | 0.690 | 0.4412 | 8.214 |
| 850 | 1.1101 | 0.8230 | 1.349 | 3.763 | 6.030 | 0.693 | 0.4153 | 9.061 |
| 900 | 1.1209 | 0.8338 | 1.344 | 3.897 | 6.276 | 0.696 | 0.3922 | 9.936 |
| 950 | 1.1313 | 0.8442 | 1.340 | 4.026 | 6.520 | 0.699 | 0.3716 | 10.83 |
| 1000 | 1.1411 | 0.8540 | 1.336 | 4.153 | 6.754 | 0.702 | 0.3530 | 11.76 |
| 1050 | 1.1502 | 0.8631 | 1.333 | 4.276 | 6.985 | 0.704 | 0.3362 | 12.72 |
| 1100 | 1.1589 | 0.8718 | 1.329 | 4.396 | 7.209 | 0.707 | 0.3209 | 13.70 |
| 1150 | 1.1670 | 0.8799 | 1.326 | 4.511 | 7.427 | 0.709 | 0.3069 | 14.70 |
| 1200 | 1.1746 | 0.8875 | 1.323 | 4.626 | 7.640 | 0.711 | 0.2941 | 15.73 |
| 1250 | 1.1817 | 0.8946 | 1.321 | 4.736 | 7.849 | 0.713 | 0.2824 | 16.77 |
| 1300 | 1.1884 | 0.9013 | 1.319 | 4.846 | 8.054 | 0.715 | 0.2715 | 17.85 |
| 1350 | 1.1946 | 0.9075 | 1.316 | 4.952 | 8.253 | 0.717 | 0.2615 | 18.94 |
| 1400 | 1.2005 | 0.9134 | 1.314 | 5.057 | 8.450 | 0.719 | 0.2521 | 20.06 |
| 1500 | 1.2112 | 0.9241 | 1.311 | 5.264 | 8.831 | 0.722 | 0.2353 | 22.36 |
| 1600 | 1.2207 | 0.9336 | 1.308 | 5.457 | 9.199 | 0.724 | 0.2206 | 24.74 |
| 1700 | 1.2293 | 0.9422 | 1.305 | 5.646 | 9.554 | 0.726 | 0.2076 | 27.20 |
| 1800 | 1.2370 | 0.9499 | 1.302 | 5.829 | 9.899 | 0.728 | 0.1961 | 29.72 |
| 1900 | 1.2440 | 0.9569 | 1.300 | 6.008 | 10.233 | 0.730 | 0.1858 | 32.34 |
| 2000 | 1.2505 | 0.9634 | 1.298 | — | — | — | 0.1765 | — |
| 2100 | 1.2564 | 0.9693 | 1.296 | — | — | — | 0.1681 | — |
| 2200 | 1.2619 | 0.9748 | 1.295 | — | — | — | 0.1604 | — |
| 2300 | 1.2669 | 0.9798 | 1.293 | — | — | — | 0.1535 | — |
| 2400 | 1.2717 | 0.9846 | 1.292 | — | — | — | 0.1471 | — |
| 2500 | 1.2762 | 0.9891 | 1.290 | — | — | — | 0.1412 | — |
| 2600 | 1.2803 | 0.9932 | 1.289 | — | — | — | 0.1358 | — |
| 2700 | 1.2843 | 0.9972 | 1.288 | — | — | — | 0.1307 | — |
| 2800 | 1.2881 | 1.0010 | 1.287 | — | — | — | 0.1261 | — |
| 2900 | 1.2916 | 1.0045 | 1.286 | — | — | — | 0.1217 | — |
| 3000 | 1.2949 | 1.0078 | 1.285 | — | — | — | 0.1177 | — |

The values for air can also be used with reasonable accuracy for CO, $N_2$ and $O_2$.

The values of the thermodynamic properties $c_v$ and $c_p$ on pp. 16 and 17 are those at zero pressure. The values for the gases are quite accurate over a wide range of pressure, but those for the vapours increase appreciably with pressure.

The transport properties $\mu$ and $k$ for air are accurate over a wide range of pressure, except at such low pressures that the mean free path of the molecules is comparable to the distance between the solid surfaces containing the gas.

At high temperatures (>1500 K for air) dissociation becomes appreciable and pressure is a significant variable for both gases and vapours: the values on pp. 16 and 17 apply only to undissociated states.

## Specific Heat $c_p$ of Some Gases and Vapours

| $T$/[K] | $CO_2$ | CO | $H_2$ | $N_2$ | $O_2$ | $H_2O$ | $CH_4$ | $C_2H_4$ | $C_2H_6$ |
|---|---|---|---|---|---|---|---|---|---|
| 175 | 0.709 | 1.039 | 13.12 | 1.039 | 0.910 | 1.850 | 2.083 | 1.241 | |
| 200 | 0.735 | 1.039 | 13.53 | 1.039 | 0.910 | 1.851 | 2.087 | 1.260 | |
| 225 | 0.763 | 1.039 | 13.83 | 1.039 | 0.911 | 1.852 | 2.121 | 1.316 | |
| 250 | 0.791 | 1.039 | 14.05 | 1.039 | 0.913 | 1.855 | 2.156 | 1.380 | 1.535 |
| 275 | 0.819 | 1.040 | 14.20 | 1.039 | 0.915 | 1.859 | 2.191 | 1.453 | 1.651 |
| 300 | 0.846 | 1.040 | 14.31 | 1.040 | 0.918 | 1.864 | 2.226 | 1.535 | 1.766 |
| 325 | 0.871 | 1.041 | 14.38 | 1.040 | 0.923 | 1.871 | 2.293 | 1.621 | 1.878 |
| 350 | 0.895 | 1.043 | 14.43 | 1.041 | 0.928 | 1.880 | 2.365 | 1.709 | 1.987 |
| 375 | 0.918 | 1.045 | 14.46 | 1.042 | 0.934 | 1.890 | 2.442 | 1.799 | 2.095 |
| 400 | 0.939 | 1.048 | 14.48 | 1.044 | 0.941 | 1.901 | 2.525 | 1.891 | 2.199 |
| 450 | 0.978 | 1.054 | 14.50 | 1.049 | 0.956 | 1.926 | 2.703 | 2.063 | 2.402 |
| 500 | 1.014 | 1.064 | 14.51 | 1.056 | 0.972 | 1.954 | 2.889 | 2.227 | 2.596 |
| 550 | 1.046 | 1.075 | 14.53 | 1.065 | 0.988 | 1.984 | 3.074 | 2.378 | 2.782 |
| 600 | 1.075 | 1.087 | 14.55 | 1.075 | 1.003 | 2.015 | 3.256 | 2.519 | 2.958 |
| 650 | 1.102 | 1.100 | 14.57 | 1.086 | 1.017 | 2.047 | 3.432 | 2.649 | 3.126 |
| 700 | 1.126 | 1.113 | 14.60 | 1.098 | 1.031 | 2.080 | 3.602 | 2.770 | 3.286 |
| 750 | 1.148 | 1.126 | 14.65 | 1.110 | 1.043 | 2.113 | 3.766 | 2.883 | 3.438 |
| 800 | 1.168 | 1.139 | 14.71 | 1.122 | 1.054 | 2.147 | 3.923 | 2.989 | 3.581 |
| 850 | 1.187 | 1.151 | 14.77 | 1.134 | 1.065 | 2.182 | 4.072 | 3.088 | 3.717 |
| 900 | 1.204 | 1.163 | 14.83 | 1.146 | 1.074 | 2.217 | 4.214 | 3.180 | 3.846 |
| 950 | 1.220 | 1.174 | 14.90 | 1.157 | 1.082 | 2.252 | 4.348 | 3.266 | |
| 1000 | 1.234 | 1.185 | 14.98 | 1.167 | 1.090 | 2.288 | 4.475 | 3.347 | |
| 1050 | 1.247 | 1.194 | 15.06 | 1.177 | 1.097 | 2.323 | 4.595 | 3.423 | |
| 1100 | 1.259 | 1.203 | 15.15 | 1.187 | 1.103 | 2.358 | 4.708 | 3.494 | |
| 1150 | 1.270 | 1.212 | 15.25 | 1.196 | 1.109 | 2.392 | 4.814 | 3.561 | |
| 1200 | 1.280 | 1.220 | 15.34 | 1.204 | 1.115 | 2.425 | | | |
| 1250 | 1.290 | 1.227 | 15.44 | 1.212 | 1.120 | 2.458 | | | |
| 1300 | 1.298 | 1.234 | 15.54 | 1.219 | 1.125 | 2.490 | | | |
| 1350 | 1.306 | 1.240 | 15.65 | 1.226 | 1.130 | 2.521 | | | |
| 1400 | 1.313 | 1.246 | 15.77 | 1.232 | 1.134 | 2.552 | | | |
| 1500 | 1.326 | 1.257 | 16.02 | 1.244 | 1.143 | 2.609 | | | |
| 1600 | 1.338 | 1.267 | 16.23 | 1.254 | 1.151 | 2.662 | | | |
| 1700 | 1.348 | 1.275 | 16.44 | 1.263 | 1.158 | 2.711 | | | |
| 1800 | 1.356 | 1.282 | 16.64 | 1.271 | 1.166 | 2.756 | | | |
| 1900 | 1.364 | 1.288 | 16.83 | 1.278 | 1.173 | 2.798 | | | |
| 2000 | 1.371 | 1.294 | 17.01 | 1.284 | 1.181 | 2.836 | | | |
| 2100 | 1.377 | 1.299 | 17.18 | 1.290 | 1.188 | 2.872 | | | |
| 2200 | 1.383 | 1.304 | 17.35 | 1.295 | 1.195 | 2.904 | | | |
| 2300 | 1.388 | 1.308 | 17.50 | 1.300 | 1.202 | 2.934 | | | |
| 2400 | 1.393 | 1.311 | 17.65 | 1.304 | 1.209 | 2.962 | | | |
| 2500 | 1.397 | 1.315 | 17.80 | 1.307 | 1.216 | 2.987 | | | |
| 2600 | 1.401 | 1.318 | 17.93 | 1.311 | 1.223 | 3.011 | | | |
| 2700 | 1.404 | 1.321 | 18.06 | 1.314 | 1.230 | 3.033 | | | |
| 2800 | 1.408 | 1.324 | 18.17 | 1.317 | 1.236 | 3.053 | | | |
| 2900 | 1.411 | 1.326 | 18.28 | 1.320 | 1.243 | 3.072 | | | |
| 3000 | 1.414 | 1.329 | 18.39 | 1.323 | 1.249 | 3.090 | | | |
| 3500 | 1.427 | 1.339 | 18.91 | 1.333 | 1.276 | 3.163 | | | |
| 4000 | 1.437 | 1.346 | 19.39 | 1.342 | 1.299 | 3.217 | | | |
| 4500 | 1.446 | 1.353 | 19.83 | 1.349 | 1.316 | 3.258 | | | |
| 5000 | 1.455 | 1.359 | 20.23 | 1.355 | 1.328 | 3.292 | | | |
| 5500 | 1.465 | 1.365 | 20.61 | 1.362 | 1.337 | 3.322 | | | |
| 6000 | 1.476 | 1.370 | 20.96 | 1.369 | 1.344 | 3.350 | | | |

| $T$/[K] | $C_6H_6$ | $C_8H_{18}$ |
|---|---|---|
| 250 | 0.850 | 1.308 |
| 275 | 0.957 | 1.484 |
| 300 | 1.060 | 1.656 |
| 325 | 1.160 | 1.825 |
| 350 | 1.255 | 1.979 |
| 375 | 1.347 | 2.109 |
| 400 | 1.435 | 2.218 |
| 450 | 1.600 | 2.403 |
| 500 | 1.752 | 2.608 |
| 550 | 1.891 | 2.774 |
| 600 | 2.018 | 2.924 |
| 650 | 2.134 | 3.121 |
| 700 | 2.239 | 3.232 |
| 750 | 2.335 | 3.349 |
| 800 | 2.422 | 3.465 |
| 850 | 2.500 | 3.582 |
| 900 | 2.571 | 3.673 |

The specific heats of atomic H, N and O are given with adequate accuracy by $c_p = 2.5\ R_0/M$ where $M$ is the molar mass of the *atomic* species.

## International Standard Atmosphere

| $z$ [m] | $p$ [bar] | $T$ [K] | $\rho/\rho_0$ | $\nu$ $10^{-5}$[m²/s] | $k$ $10^{-5}$[kW/m K] | $a$ [m/s] | $\lambda$ $10^{-8}$[m] |
|---|---|---|---|---|---|---|---|
| −2500 | 1.3521 | 304.4 | 1.2631 | 1.207 | 2.661 | 349.8 | 5.251 |
| −2000 | 1.2778 | 301.2 | 1.2067 | 1.253 | 2.636 | 347.9 | 5.497 |
| −1500 | 1.2070 | 297.9 | 1.1522 | 1.301 | 2.611 | 346.0 | 5.757 |
| −1000 | 1.1393 | 294.7 | 1.0996 | 1.352 | 2.585 | 344.1 | 6.032 |
| − 500 | 1.0748 | 291.4 | 1.0489 | 1.405 | 2.560 | 342.2 | 6.324 |
| 0 | 1.01325 | 288.15 | 1.0000 | 1.461 | 2.534 | 340.3 | 6.633 |
| 500 | 0.9546 | 284.9 | 0.9529 | 1.520 | 2.509 | 338.4 | 6.961 |
| 1000 | 0.8988 | 281.7 | 0.9075 | 1.581 | 2.483 | 336.4 | 7.309 |
| 1500 | 0.8456 | 278.4 | 0.8638 | 1.646 | 2.457 | 334.5 | 7.679 |
| 2000 | 0.7950 | 275.2 | 0.8217 | 1.715 | 2.431 | 332.5 | 8.072 |
| 2500 | 0.7469 | 271.9 | 0.7812 | 1.787 | 2.405 | 330.6 | 8.491 |
| 3000 | 0.7012 | 268.7 | 0.7423 | 1.863 | 2.379 | 328.6 | 8.936 |
| 3500 | 0.6578 | 265.4 | 0.7048 | 1.943 | 2.353 | 326.6 | 9.411 |
| 4000 | 0.6166 | 262.2 | 0.6689 | 2.028 | 2.327 | 324.6 | 9.917 |
| 4500 | 0.5775 | 258.9 | 0.6343 | 2.117 | 2.301 | 322.6 | 10.46 |
| 5000 | 0.5405 | 255.7 | 0.6012 | 2.211 | 2.275 | 320.5 | 11.03 |
| 5500 | 0.5054 | 252.4 | 0.5694 | 2.311 | 2.248 | 318.5 | 11.65 |
| 6000 | 0.4722 | 249.2 | 0.5389 | 2.416 | 2.222 | 316.5 | 12.31 |
| 6500 | 0.4408 | 245.9 | 0.5096 | 2.528 | 2.195 | 314.4 | 13.02 |
| 7000 | 0.4111 | 242.7 | 0.4817 | 2.646 | 2.169 | 312.3 | 13.77 |
| 7500 | 0.3830 | 239.5 | 0.4549 | 2.771 | 2.142 | 310.2 | 14.58 |
| 8000 | 0.3565 | 236.2 | 0.4292 | 2.904 | 2.115 | 308.1 | 15.45 |
| 8500 | 0.3315 | 233.0 | 0.4047 | 3.046 | 2.088 | 306.0 | 16.39 |
| 9000 | 0.3080 | 229.7 | 0.3813 | 3.196 | 2.061 | 303.8 | 17.40 |
| 9500 | 0.2858 | 226.5 | 0.3589 | 3.355 | 2.034 | 301.7 | 18.48 |
| 10000 | 0.2650 | 223.3 | 0.3376 | 3.525 | 2.007 | 299.5 | 19.65 |
| 10500 | 0.2454 | 220.0 | 0.3172 | 3.706 | 1.980 | 297.4 | 20.91 |
| 11000 | 0.2270 | 216.8 | 0.2978 | 3.899 | 1.953 | 295.2 | 22.27 |
| 11500 | 0.2098 | 216.7 | 0.2755 | 4.213 | 1.952 | 295.1 | 24.08 |
| 12000 | 0.1940 | 216.7 | 0.2546 | 4.557 | 1.952 | 295.1 | 26.05 |
| 12500 | 0.1793 | 216.7 | 0.2354 | 4.930 | 1.952 | 295.1 | 28.18 |
| 13000 | 0.1658 | 216.7 | 0.2176 | 5.333 | 1.952 | 295.1 | 30.48 |
| 13500 | 0.1533 | 216.7 | 0.2012 | 5.768 | 1.952 | 295.1 | 32.97 |
| 14000 | 0.1417 | 216.7 | 0.1860 | 6.239 | 1.952 | 295.1 | 35.66 |
| 14500 | 0.1310 | 216.7 | 0.1720 | 6.749 | 1.952 | 295.1 | 38.57 |
| 15000 | 0.1211 | 216.7 | 0.1590 | 7.300 | 1.952 | 295.1 | 41.72 |
| 15500 | 0.1120 | 216.7 | 0.1470 | 7.895 | 1.952 | 295.1 | 45.13 |
| 16000 | 0.1035 | 216.7 | 0.1359 | 8.540 | 1.952 | 295.1 | 48.81 |
| 16500 | 0.09572 | 216.7 | 0.1256 | 9.237 | 1.952 | 295.1 | 52.79 |
| 17000 | 0.08850 | 216.7 | 0.1162 | 9.990 | 1.952 | 295.1 | 57.10 |
| 17500 | 0.08182 | 216.7 | 0.1074 | 10.805 | 1.952 | 295.1 | 61.76 |
| 18000 | 0.07565 | 216.7 | 0.09930 | 11.686 | 1.952 | 295.1 | 66.79 |
| 18500 | 0.06995 | 216.7 | 0.09182 | 12.639 | 1.952 | 295.1 | 72.24 |
| 19000 | 0.06467 | 216.7 | 0.08489 | 13.670 | 1.952 | 295.1 | 78.13 |
| 19500 | 0.05980 | 216.7 | 0.07850 | 14.784 | 1.952 | 295.1 | 84.50 |
| 20000 | 0.05529 | 216.7 | 0.07258 | 15.989 | 1.952 | 295.1 | 91.39 |
| 22000 | 0.04047 | 218.6 | 0.05266 | 22.201 | 1.968 | 296.4 | 126.0 |
| 24000 | 0.02972 | 220.6 | 0.03832 | 30.743 | 1.985 | 297.7 | 173.1 |
| 26000 | 0.02188 | 222.5 | 0.02797 | 42.439 | 2.001 | 299.1 | 237.2 |
| 28000 | 0.01616 | 224.5 | 0.02047 | 58.405 | 2.018 | 300.4 | 324.0 |
| 30000 | 0.01197 | 226.5 | 0.01503 | 80.134 | 2.034 | 301.7 | 441.3 |
| 32000 | 0.00889 | 228.5 | 0.01107 | 109.62 | 2.051 | 303.0 | 599.4 |

Density at sea level $\rho_0 = 1.2250$ kg/m³

## SI – British Conversion Factors

*The International System of Units* (HMSO, 1977) may be consulted for the definitions of SI units, and *British Standard* 350 for comprehensive tables of conversion factors.

*Exact values are printed in* **bold type.**

Mass: $\mathbf{1\ kg} = \frac{\mathbf{1}}{\mathbf{0.453\,592\,37}}\ \text{lb} = 2.205\ \text{lb}$

Length: $1\ \text{m} = \frac{\mathbf{1}}{\mathbf{0.3048}}\ \text{ft} = 3.281\ \text{ft}$

Volume: $1\ \text{m}^3 = 10^3\ \text{dm}^3\ \text{(litre)} = 35.31\ \text{ft}^3 = 220.0\ \text{UK gal}$

Time: $1\ \text{s} = \frac{\mathbf{1}}{\mathbf{60}}\ \text{min} = \frac{\mathbf{1}}{\mathbf{3600}}\ \text{h}$

Temperature unit: $1\ \text{K} = \mathbf{1.8}\ \text{R}$ (see p. 11 for definitions of units and scales)

Force: $1\ \text{N (or kg m/s}^2) = \mathbf{10^5}\ \text{dyn} = \frac{\mathbf{1}}{\mathbf{9.806\,65}}\ \text{kgf}$

$$= 7.233\ \text{pdl} = \frac{7.233}{32.174}\ \text{or}\ 0.2248\ \text{lbf}$$

Pressure $p$: $1\ \text{bar} = \mathbf{10^5}\ \text{N/m}^2\ \text{(or Pa)} = 14.50\ \text{lbf/in}^2 = 750\ \text{mmHg} = 10.20\ \text{mH}_2\text{O}$

Specific volume $v$: $1\ \text{m}^3/\text{kg} = 16.02\ \text{ft}^3/\text{lb}$

Density $\rho$: $1\ \text{kg/m}^3 = 0.062\,43\ \text{lb/ft}^3$

Energy: $1\ \text{kJ} = \mathbf{10^3}\ \text{N m} = \frac{\mathbf{1}}{\mathbf{4.1868}}\ \text{kcal}_{\text{IT}} = 0.9478\ \text{Btu} = 737.6\ \text{ft lbf}$

Power: $1\ \text{kW} = \mathbf{1}\ \text{kJ/s} = \frac{\mathbf{10^3}}{\mathbf{9.806\,65}}\ \text{kgf m/s} = \frac{\mathbf{10^3}}{\mathbf{9.806\,65 \times 75}}\ \text{metric hp}$

$$= 737.6\ \text{ft lbf/s} = \frac{737.6}{550}\ \text{or}\ \frac{1}{0.7457}\ \text{British hp} = 3412\ \text{Btu/h}$$

Specific energy etc. ($u$, $h$): $1\ \text{kJ/kg} = \frac{\mathbf{1}}{\mathbf{2.326}}\ \text{Btu/lb} = 0.4299\ \text{Btu/lb}$

Specific heat etc. ($c$, $R$, $s$): $1\ \text{kJ/kg K} = \frac{\mathbf{1}}{\mathbf{4.1868}}\ \text{Btu/lb R} = 0.2388\ \text{Btu/lb R}$

Thermal conductivity $k$: $1\ \text{kW/m K} = 577.8\ \text{Btu/ft h R}$

Heat transfer coefficient: $1\ \text{kW/m}^2\ \text{K} = 176.1\ \text{Btu/ft}^2\ \text{h R}$

Dynamic viscosity $\mu$: $1\ \text{kg/m s} = \mathbf{1}\ \text{N s/m}^2 = 1\ \text{Pa s} = \mathbf{10}\ \text{dyn s/cm}^2\ \text{(or poise})$
$= 2419\ \text{lb/ft h} = 18.67 \times 10^{-5}\ \text{pdl h/ft}^2$

Kinematic viscosity $v$: $1\ \text{m}^2/\text{s} = \mathbf{10^4}\ \text{cm}^2/\text{s (or stokes)} = 38\,750\ \text{ft}^2/\text{h}$

## General Information

*Standard acceleration:* $g_n = 9.806\,65 \text{ m/s}^2 = 32.1740 \text{ ft/s}^2$

*Standard atmospheric pressure*: 1 atm = **1.013 25** bar

$= 760 \text{ mmHg} = 10.33 \text{ mH}_2\text{O} = 1.0332 \text{ kgf/cm}^2$
$= 29.92 \text{ inHg} = 33.90 \text{ ftH}_2\text{O} = 14.696 \text{ lbf/in}^2$

*Molar (universal) gas constant*: $R_0 = 8.3144$ kJ/kmol K†
$= 1.986$ Btu/lb-mol R $= 1545$ ft lbf/lb-mol R

1 kmol occupies 22.41 $\text{m}^3$ at 1 atm and 0 °C
1 lb-mol occupies 359.0 $\text{ft}^3$ at 1 atm and 32 °F

*Composition of air*:

| | vol. analysis | grav. analysis |
|---|---|---|
| Nitrogen ($N_2$ – 28.013 kg/kmol) | 0.7809 | 0.7553 |
| Oxygen ($O_2$ – 31.999 kg/kmol) | 0.2095 | 0.2314 |
| Argon (Ar – 39.948 kg/kmol) | 0.0093 | 0.0128 |
| Carbon dioxide ($CO_2$ – 44.010 kg/kmol) | 0.0003 | 0.0005 |

Molar mass $M = 28.96$ kg/kmol
Specific gas constant $R = 0.2871$ kJ/kg K
$= 0.068\,56$ Btu/lb R $= 53.35$ ft lbf/lb R

See p. 16 for other properties

For approximate calculations with air:

| | | vol. analysis | grav. analysis |
|---|---|---|---|
| $N_2$ – 28 kg/kmol | | 0.79 | 0.767 |
| $O_2$ – 32 kg/kmol | | 0.21 | 0.233 |
| $N_2/O_2$ | | 3.76 | 3.29 |
| Molar mass $M$ | = 29 kg/kmol | | |
| Specific gas constant $R$ | = 0.287 kJ/kg K | | |
| = 0.0685 Btu/lb R | = 53.3 ft lbf/lb R | | |
| $c_p = 1.005$ kJ/kg K | = 0.240 Btu/lb R | | |
| $c_v = 0.718$ kJ/kg K | = 0.1715 Btu/lb R | | |
| $c_p/c_v = \gamma = 1.40$ | | | |

*The Stefan-Boltzmann constant*:

$\sigma = 56.7 \times 10^{-12} \text{ kW/m}^2 \text{ K}^4 = 0.171 \times 10^{-8} \text{ Btu/ft}^2 \text{ h R}^4$

† The kilomole (kmol) is the amount of substance of a system which contains as many elementary entities as there are atoms in 12 kg of carbon 12.
The elementary entities must be specified, but for problems involving mixtures of gases and combustion they will be molecules or atoms.

**FOR USE WITH THESE TABLES**

*Enthalpy-Entropy Diagram for Steam*

*Pressure-Enthalpy Diagram for Refrigerant 12*
(Dichlorodifluoromethane, $CF_2Cl_2$)

*Pressure-Enthalpy Diagram for Ammonia*
(Refrigant 717, $NH_3$)

*Prepared by* D. C. Hickson *and* F. R. Taylor

*Diagram for Temperature Rise* v. *Fuel/Air Ratio for Combustion of a Gas Turbine Fuel*

*Prepared by* G. F. C. Rogers and Y. R. Mayhew

BASIL BLACKWELL