Table 1 .... Properties of Dichlorodifluoromethane ($CCl_2F_2$)[a]

| Sat. Temp. F | Abs. Press. Lb per Sq In. | Volume | | Enthalpy and Entropy Taken From —40 F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Enthalpy | | Entropy | | 25 F Superheat | | 50 F Superheat | |
| | | Liquid | Vapor | Liquid | Vapor | Liquid | Vapor | Enthalpy | Entropy | Enthalpy | Entropy |
| 0 | 23.87 | 0.0110 | 1.637 | 8.25 | 78.21 | 0.01869 | 0.17091 | 81.71 | 0.17829 | 85.26 | 0.18547 |
| 2 | 24.89 | 0.0110 | 1.574 | 8.67 | 78.44 | 0.01961 | 0.17075 | 81.94 | 0.17812 | 85.51 | 0.18529 |
| 4 | 25.96 | 0.0111 | 1.514 | 9.10 | 78.67 | 0.02052 | 0.17060 | 82.17 | 0.17795 | 85.76 | 0.18511 |
| 5 | 26.51 | 0.0111 | 1.485 | 9.32 | 78.79 | 0.02097 | 0.17052 | 82.29 | 0.17786 | 85.89 | 0.18502 |
| 6 | 27.05 | 0.0111 | 1.457 | 9.53 | 78.90 | 0.02143 | 0.17045 | 82.41 | 0.17778 | 86.01 | 0.18494 |
| 8 | 28.18 | 0.0111 | 1.403 | 9.96 | 79.13 | 0.02235 | 0.17030 | 82.66 | 0.17763 | 86.26 | 0.18477 |
| 10 | 29.35 | 0.0112 | 1.351 | 10.39 | 79.36 | 0.02328 | 0.17015 | 82.90 | 0.17747 | 86.51 | 0.18460 |
| 12 | 30.56 | 0.0112 | 1.301 | 10.82 | 79.59 | 0.02419 | 0.17001 | 83.14 | 0.17733 | 86.76 | 0.18444 |
| 14 | 31.80 | 0.0112 | 1.253 | 11.26 | 79.82 | 0.02510 | 0.16987 | 83.38 | 0.17720 | 87.01 | 0.18429 |
| 16 | 33.08 | 0.0112 | 1.207 | 11.70 | 80.05 | 0.02601 | 0.16974 | 83.61 | 0.17706 | 87.26 | 0.18413 |
| 18 | 34.40 | 0.0113 | 1.163 | 12.12 | 80.27 | 0.02692 | 0.16961 | 83.85 | 0.17693 | 87.51 | 0.18397 |
| 20 | 35.75 | 0.0113 | 1.121 | 12.55 | 80.49 | 0.02783 | 0.16949 | 84.09 | 0.17679 | 87.76 | 0.18382 |
| 22 | 37.15 | 0.0113 | 1.081 | 13.00 | 80.72 | 0.02873 | 0.16938 | 84.32 | 0.17666 | 88.00 | 0.18369 |
| 24 | 38.58 | 0.0113 | 1.043 | 13.44 | 80.95 | 0.02963 | 0.16926 | 84.55 | 0.17652 | 88.24 | 0.18355 |
| 26 | 40.07 | 0.0114 | 1.007 | 13.88 | 81.17 | 0.03053 | 0.16913 | 84.79 | 0.17639 | 88.49 | 0.18342 |
| 28 | 41.59 | 0.0114 | 0.973 | 14.32 | 81.39 | 0.03143 | 0.16900 | 85.02 | 0.17625 | 88.73 | 0.18328 |
| 30 | 43.16 | 0.0115 | 0.939 | 14.76 | 81.61 | 0.03233 | 0.16887 | 85.25 | 0.17612 | 88.97 | 0.18315 |
| 32 | 44.77 | 0.0115 | 0.908 | 15.21 | 81.83 | 0.03323 | 0.16876 | 85.48 | 0.17600 | 89.21 | 0.18303 |
| 34 | 46.42 | 0.0115 | 0.877 | 15.65 | 82.05 | 0.03413 | 0.16865 | 85.71 | 0.17589 | 89.45 | 0.18291 |
| 36 | 48.13 | 0.0116 | 0.848 | 16.10 | 82.27 | 0.03502 | 0.16854 | 85.95 | 0.17577 | 89.68 | 0.18280 |
| 38 | 49.88 | 0.0116 | 0.819 | 16.55 | 82.49 | 0.03591 | 0.16843 | 86.18 | 0.17566 | 89.92 | 0.18268 |
| 39 | 50.78 | 0.0116 | 0.806 | 16.77 | 82.60 | 0.03635 | 0.16838 | 86.29 | 0.17560 | 90.04 | 0.18262 |
| 40 | 51.68 | 0.0116 | 0.792 | 17.00 | 82.71 | 0.03680 | 0.16833 | 86.41 | 0.17554 | 90.16 | 0.18256 |
| 41 | 52.70 | 0.0116 | 0.779 | 17.23 | 82.82 | 0.03725 | 0.16828 | 86.52 | 0.17549 | 90.28 | 0.18251 |
| 42 | 53.51 | 0.0116 | 0.767 | 17.46 | 82.93 | 0.03770 | 0.16823 | 86.64 | 0.17544 | 90.40 | 0.18245 |
| 44 | 55.40 | 0.0117 | 0.742 | 17.91 | 83.15 | 0.03859 | 0.16813 | 86.86 | 0.17534 | 90.65 | 0.18235 |
| 46 | 57.35 | 0.0117 | 0.718 | 18.36 | 83.36 | 0.03948 | 0.16803 | 87.09 | 0.17525 | 90.89 | 0.18224 |
| 48 | 59.35 | 0.0117 | 0.695 | 18.82 | 83.57 | 0.04037 | 0.16794 | 87.31 | 0.17515 | 91.14 | 0.18214 |
| 50 | 61.39 | 0.0118 | 0.673 | 19.27 | 83.78 | 0.04126 | 0.16785 | 87.54 | 0.17505 | 91.38 | 0.18203 |
| 52 | 63.49 | 0.0118 | 0.652 | 19.72 | 83.99 | 0.04215 | 0.16776 | 87.76 | 0.17496 | 91.61 | 0.18193 |
| 54 | 65.63 | 0.0118 | 0.632 | 20.18 | 84.20 | 0.04304 | 0.16767 | 87.98 | 0.17486 | 91.83 | 0.18184 |
| 56 | 67.84 | 0.0119 | 0.612 | 20.64 | 84.41 | 0.04392 | 0.16758 | 88.20 | 0.17477 | 92.06 | 0.18174 |
| 58 | 70.10 | 0.0119 | 0.593 | 21.11 | 84.62 | 0.04480 | 0.16749 | 88.42 | 0.17467 | 92.28 | 0.18165 |
| 60 | 72.41 | 0.0119 | 0.575 | 21.57 | 84.82 | 0.04568 | 0.16741 | 88.64 | 0.17458 | 92.51 | 0.18155 |
| 62 | 74.77 | 0.0120 | 0.557 | 22.03 | 85.02 | 0.04657 | 0.16733 | 88.86 | 0.17450 | 92.74 | 0.18147 |
| 64 | 77.20 | 0.0120 | 0.540 | 22.49 | 85.22 | 0.04745 | 0.16725 | 89.07 | 0.17442 | 92.97 | 0.18139 |
| 66 | 79.67 | 0.0120 | 0.524 | 22.95 | 85.42 | 0.04833 | 0.16717 | 89.29 | 0.17433 | 93.20 | 0.18130 |
| 68 | 82.24 | 0.0121 | 0.508 | 23.42 | 85.62 | 0.04921 | 0.16709 | 89.50 | 0.17425 | 93.43 | 0.18122 |
| 70 | 84.82 | 0.0121 | 0.493 | 23.90 | 85.82 | 0.05009 | 0.16701 | 89.72 | 0.17417 | 93.66 | 0.18114 |
| 72 | 87.50 | 0.0121 | 0.479 | 24.37 | 86.02 | 0.05097 | 0.16693 | 89.93 | 0.17409 | 93.99 | 0.18106 |
| 74 | 90.20 | 0.0122 | 0.464 | 24.84 | 86.22 | 0.05185 | 0.16685 | 90.14 | 0.17402 | 94.12 | 0.18098 |
| 76 | 93.00 | 0.0122 | 0.451 | 25.32 | 86.42 | 0.05272 | 0.16677 | 90.36 | 0.17394 | 94.34 | 0.18091 |
| 78 | 95.85 | 0.0123 | 0.438 | 25.80 | 86.61 | 0.05359 | 0.16669 | 90.57 | 0.17387 | 94.57 | 0.18083 |
| 80 | 98.76 | 0.0123 | 0.425 | 26.28 | 86.80 | 0.05446 | 0.16662 | 90.78 | 0.17379 | 94.80 | 0.18075 |
| 82 | 101.70 | 0.0123 | 0.413 | 26.76 | 86.99 | 0.05534 | 0.16655 | 90.98 | 0.17372 | 95.01 | 0.18068 |
| 84 | 104.8 | 0.0124 | 0.401 | 27.24 | 87.18 | 0.05621 | 0.16648 | 91.18 | 0.17365 | 95.22 | 0.18061 |
| 86 | 107.9 | 0.0124 | 0.389 | 27.72 | 87.37 | 0.05708 | 0.16640 | 91.37 | 0.17358 | 95.44 | 0.18054 |
| 88 | 111.1 | 0.0124 | 0.378 | 28.21 | 87.56 | 0.05795 | 0.16632 | 91.57 | 0.17351 | 95.65 | 0.18047 |
| 90 | 114.3 | 0.0125 | 0.368 | 28.70 | 87.74 | 0.05882 | 0.16624 | 91.77 | 0.17344 | 95.86 | 0.18040 |
| 92 | 117.7 | 0.0125 | 0.357 | 29.19 | 87.92 | 0.05969 | 0.16616 | 91.97 | 0.17337 | 96.07 | 0.18033 |



Table 1 .... Properties of Dichlorodifluoromethane ($CCl_2F_2$)[a] (*Concluded*)

| Sat. Temp. F | Abs. Press. Lb per Sq In. | Volume | | Enthalpy and Entropy Taken From —40 F | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Enthalpy | | Entropy | | 25 F Superheat | | 50 F Superheat | |
| | | Liquid | Vapor | Liquid | Vapor | Liquid | Vapor | Enthalpy | Entropy | Enthalpy | Entropy |
| 94 | 121.0 | 0.0126 | 0.347 | 29.68 | 88.10 | 0.06056 | 0.16608 | 92.16 | 0.17330 | 96.28 | 0.18026 |
| 96 | 124.5 | 0.0126 | 0.338 | 30.18 | 88.28 | 0.06143 | 0.16600 | 92.36 | 0.17322 | 96.50 | 0.18018 |
| 98 | 128.0 | 0.0126 | 0.328 | 30.67 | 88.45 | 0.06230 | 0.16592 | 92.55 | 0.17315 | 96.71 | 0.18011 |
| 100 | 131.6 | 0.0127 | 0.319 | 31.16 | 88.62 | 0.06316 | 0.16584 | 92.75 | 0.17308 | 96.92 | 0.18004 |
| 102 | 135.3 | 0.0127 | 0.310 | 31.65 | 88.79 | 0.06403 | 0.16576 | 92.93 | 0.17301 | 97.12 | 0.17998 |
| 104 | 139.0 | 0.0128 | 0.302 | 32.15 | 88.95 | 0.06490 | 0.16568 | 93.11 | 0.17294 | 97.32 | 0.17993 |
| 106 | 142.8 | 0.0128 | 0.293 | 32.65 | 89.11 | 0.06577 | 0.16560 | 93.30 | 0.17288 | 97.53 | 0.17987 |
| 108 | 146.8 | 0.0129 | 0.285 | 33.15 | 89.27 | 0.06663 | 0.16551 | 93.48 | 0.17281 | 97.73 | 0.17982 |
| 110 | 150.7 | 0.0129 | 0.277 | 33.65 | 89.43 | 0.06749 | 0.16542 | 93.66 | 0.17274 | 97.93 | 0.17976 |
| 112 | 154.8 | 0.0130 | 0.269 | 34.15 | 89.58 | 0.06836 | 0.16533 | 93.82 | 0.17266 | 98.11 | 0.17969 |
| 114 | 158.9 | 0.0130 | 0.262 | 34.65 | 89.73 | 0.06922 | 0.16524 | 93.98 | 0.17258 | 98.29 | 0.17961 |
| 116 | 163.1 | 0.0131 | 0.254 | 35.15 | 89.87 | 0.07008 | 0.16515 | 94.15 | 0.17249 | 98.48 | 0.17954 |
| 118 | 167.4 | 0.0131 | 0.247 | 35.65 | 90.01 | 0.07094 | 0.16505 | 94.31 | 0.17241 | 98.66 | 0.17946 |
| 120 | 171.8 | 0.0132 | 0.240 | 36.16 | 90.15 | 0.07180 | 0.16495 | 94.47 | 0.17233 | 98.84 | 0.17939 |
| 122 | 176.2 | 0.0132 | 0.233 | 36.66 | 90.28 | 0.07266 | 0.16484 | 94.63 | 0.17224 | 99.01 | 0.17931 |
| 124 | 180.8 | 0.0133 | 0.227 | 37.16 | 90.40 | 0.07352 | 0.16473 | 94.78 | 0.17215 | 99.18 | 0.17922 |
| 126 | 185.4 | 0.0133 | 0.220 | 37.67 | 90.52 | 0.07437 | 0.16462 | 94.94 | 0.17206 | 99.35 | 0.17914 |
| 128 | 190.1 | 0.0134 | 0.214 | 38.18 | 90.64 | 0.07522 | 0.16450 | 95.09 | 0.17196 | 99.53 | 0.17906 |
| 130 | 194.9 | 0.0134 | 0.208 | 38.69 | 90.76 | 0.07607 | 0.16438 | 95.25 | 0.17186 | 99.70 | 0.17897 |
| 132 | 199.8 | 0.0135 | 0.202 | 39.19 | 90.86 | 0.07691 | 0.16425 | 95.41 | 0.17176 | 99.87 | 0.17889 |
| 134 | 204.8 | 0.0135 | 0.196 | 39.70 | 90.96 | 0.07775 | 0.16411 | 95.56 | 0.17166 | 100.04 | 0.17881 |
| 136 | 209.9 | 0.0136 | 0.191 | 40.21 | 91.06 | 0.07858 | 0.16396 | 95.72 | 0.17156 | 100.22 | 0.17873 |
| 138 | 215.0 | 0.0137 | 0.185 | 40.72 | 91.15 | 0.07941 | 0.16380 | 95.87 | 0.17145 | 100.39 | 0.17864 |
| 140 | 220.2 | 0.0138 | 0.180 | 41.24 | 91.24 | 0.08024 | 0.16363 | 96.03 | 0.17134 | 100.56 | 0.17856 |

[a] ASRE designation—Refrigerant 12.

to restore the refrigerant to a condition in which it will possess the ability to extract heat from the space to be cooled. For all compression-type systems the cycle consists of four *processes*: heat gain in the evaporator; pressure rise in the compressor; heat loss in the condenser; pressure loss in the expansion valve. The compression process is accomplished at the expense of energy added to the compressor in the form of shaft work, and the expansion process could be carried out, if the economics of the system would permit, *in an expanding engine with consequent release of energy as shaft work.* In ordinary systems, however, the additional first cost and maintenance cost of an expanding engine so greatly exceed the advantage resulting from the work realized, that such engines are not used, and instead, the pressure reduction is allowed to occur irreversibly in an expansion valve. Basically, then, a refrigeration cycle *consists of two heat-transfer processes* and two pressure-change processes, no work entering into the heat-transfer processes and—in the simple cycle—no heat transfer occurring during the pressure-change processes.

The most common and least complicated type of refrigeration cycle is called the simple saturation cycle, and is shown *diagrammatically in* Fig. 3 *and plotted upon pressure-enthalpy coordinates* in Fig. 4. For this system, saturated vapor flows without gain or loss of heat from the evaporator to the suction of the compressor. During passage through the compressor the energy added as shaft work goes entirely to increase the enthalpy of the refrigerant, and the compression process, which is assumed to occur reversibly and without external heat transfer, *is characterized by constant entropy.* Thus, the state of the superheated vapor leaving the compressor can be determined from the tables of thermodynamic properties by noting the discharge pressure and fixing, also, the entropy of the saturated vapor at entrance to the compressor.

Superheated vapor from the compressor flows to the con*denser* where de-superheating and condensation take place. From the condenser the refrigerant flows to the expansion valve, undergoes a constant-enthalpy pressure reduction, and returns to the evaporator where it again removes a quantity of undesired heat. When the evaporator is arranged to permit direct cooling of room air by the refrigerant, the *system is* said to be of the *direct-expansion* type, while a system in which the evaporating refrigerant cools water or brine, which in turn cools the air, is said to be *indirect*. Although many differences exist between most actual systems and that of the simple saturation cycle, this latter is, nonetheless, of great value in that it provides an extremely simple method of rapidly achieving an approximate analysis of probable power requirements, compressor size, etc. Further, the equations used in analysis of a simple saturation cycle form the basis of the more complex treatments required for compound refrigeration cycles. For these reasons a typical simple saturation problem will be worked in detail.

*Example 1:* A simple saturation cycle carries a 7-ton load when operating between suction and discharge pressure of