

APPENDIX D (continued)

Prandtl Meyer functions ( $\gamma = 1.4$ )

| M    | $\nu$  | $\mu$ | M    | $\nu$  | $\mu$ | M | $\nu$ | $\mu$ |
|------|--------|-------|------|--------|-------|---|-------|-------|
| 2.20 | 31.732 | 27.04 | 2.85 | 46.778 | 20.54 |   |       |       |
| 2.21 | 31.991 | 26.97 | 2.86 | 46.962 | 20.47 |   |       |       |
| 2.22 | 32.250 | 26.90 | 2.87 | 47.146 | 20.39 |   |       |       |
| 2.23 | 32.507 | 26.84 | 2.88 | 47.330 | 20.32 |   |       |       |
| 2.24 | 32.763 | 26.81 | 2.89 | 47.514 | 20.24 |   |       |       |
| 2.25 | 33.018 | 26.79 | 2.90 | 47.700 | 20.17 |   |       |       |
| 2.26 | 33.273 | 26.76 | 2.91 | 47.886 | 20.10 |   |       |       |
| 2.27 | 33.527 | 26.74 | 2.92 | 48.072 | 20.03 |   |       |       |
| 2.28 | 33.780 | 26.71 | 2.93 | 48.258 | 19.96 |   |       |       |
| 2.29 | 34.032 | 26.69 | 2.94 | 48.444 | 19.89 |   |       |       |
| 2.30 | 34.283 | 26.67 | 2.95 | 48.630 | 19.81 |   |       |       |
| 2.31 | 34.533 | 26.65 | 2.96 | 48.816 | 19.75 |   |       |       |
| 2.32 | 34.783 | 26.63 | 2.97 | 49.002 | 19.68 |   |       |       |
| 2.33 | 35.031 | 26.62 | 2.98 | 49.188 | 19.61 |   |       |       |
| 2.34 | 35.279 | 26.60 | 2.99 | 49.374 | 19.54 |   |       |       |
| 2.35 | 35.526 | 26.58 | 3.00 | 49.560 | 19.47 |   |       |       |
| 2.36 | 35.771 | 26.57 | 3.01 | 49.746 | 19.40 |   |       |       |
| 2.37 | 36.017 | 26.55 | 3.02 | 49.932 | 19.34 |   |       |       |
| 2.38 | 36.261 | 26.54 | 3.03 | 50.118 | 19.27 |   |       |       |
| 2.39 | 36.504 | 26.53 | 3.04 | 50.304 | 19.20 |   |       |       |
| 2.40 | 36.746 | 26.52 | 3.05 | 50.490 | 19.14 |   |       |       |
| 2.41 | 36.988 | 26.51 | 3.06 | 50.676 | 19.07 |   |       |       |
| 2.42 | 37.229 | 26.49 | 3.07 | 50.862 | 19.01 |   |       |       |
| 2.43 | 37.469 | 26.48 | 3.08 | 51.048 | 18.95 |   |       |       |
| 2.44 | 37.708 | 26.47 | 3.09 | 51.234 | 18.88 |   |       |       |
| 2.45 | 37.946 | 26.46 | 3.10 | 51.420 | 18.82 |   |       |       |
| 2.46 | 38.183 | 26.45 | 3.11 | 51.606 | 18.76 |   |       |       |
| 2.47 | 38.420 | 26.44 | 3.12 | 51.792 | 18.69 |   |       |       |
| 2.48 | 38.655 | 26.43 | 3.13 | 51.978 | 18.63 |   |       |       |
| 2.49 | 38.890 | 26.42 | 3.14 | 52.164 | 18.57 |   |       |       |
| 2.50 | 39.124 | 26.41 | 3.15 | 52.350 | 18.51 |   |       |       |
| 2.51 | 39.357 | 26.40 | 3.16 | 52.536 | 18.45 |   |       |       |
| 2.52 | 39.589 | 26.39 | 3.17 | 52.722 | 18.39 |   |       |       |
| 2.53 | 39.820 | 26.38 | 3.18 | 52.908 | 18.33 |   |       |       |
| 2.54 | 40.050 | 26.37 | 3.19 | 53.094 | 18.27 |   |       |       |
| 2.55 | 40.280 | 26.36 | 3.20 | 53.280 | 18.21 |   |       |       |
| 2.56 | 40.509 | 26.35 | 3.21 | 53.466 | 18.15 |   |       |       |
| 2.57 | 40.736 | 26.34 | 3.22 | 53.652 | 18.09 |   |       |       |
| 2.58 | 40.963 | 26.33 | 3.23 | 53.838 | 18.03 |   |       |       |
| 2.59 | 41.189 | 26.32 | 3.24 | 54.024 | 17.97 |   |       |       |
| 2.60 | 41.415 | 26.31 | 3.25 | 54.210 | 17.91 |   |       |       |
| 2.61 | 41.639 | 26.30 | 3.26 | 54.396 | 17.85 |   |       |       |
| 2.62 | 41.863 | 26.29 | 3.27 | 54.582 | 17.79 |   |       |       |
| 2.63 | 42.086 | 26.28 | 3.28 | 54.768 | 17.73 |   |       |       |
| 2.64 | 42.307 | 26.27 | 3.29 | 54.954 | 17.67 |   |       |       |
| 2.65 | 42.529 | 26.26 | 3.30 | 55.140 | 17.61 |   |       |       |
| 2.66 | 42.749 | 26.25 | 3.31 | 55.326 | 17.55 |   |       |       |
| 2.67 | 42.968 | 26.24 | 3.32 | 55.512 | 17.49 |   |       |       |
| 2.68 | 43.187 | 26.23 | 3.33 | 55.698 | 17.43 |   |       |       |
| 2.69 | 43.405 | 26.22 | 3.34 | 55.884 | 17.37 |   |       |       |
| 2.70 | 43.621 | 26.21 | 3.35 | 56.070 | 17.31 |   |       |       |
| 2.71 | 43.838 | 26.20 | 3.36 | 56.256 | 17.25 |   |       |       |
| 2.72 | 44.053 | 26.19 | 3.37 | 56.442 | 17.19 |   |       |       |
| 2.73 | 44.267 | 26.18 | 3.38 | 56.628 | 17.13 |   |       |       |
| 2.74 | 44.481 | 26.17 | 3.39 | 56.814 | 17.07 |   |       |       |
| 2.75 | 44.694 | 26.16 | 3.40 | 57.000 | 17.01 |   |       |       |
| 2.76 | 44.906 | 26.15 | 3.41 | 57.186 | 16.95 |   |       |       |
| 2.77 | 45.117 | 26.14 | 3.42 | 57.372 | 16.89 |   |       |       |
| 2.78 | 45.327 | 26.13 | 3.43 | 57.558 | 16.83 |   |       |       |
| 2.79 | 45.537 | 26.12 | 3.44 | 57.744 | 16.77 |   |       |       |
| 2.80 | 45.746 | 26.11 | 3.45 | 57.930 | 16.71 |   |       |       |
| 2.81 | 45.954 | 26.10 | 3.46 | 58.116 | 16.65 |   |       |       |
| 2.82 | 46.161 | 26.09 | 3.47 | 58.302 | 16.59 |   |       |       |
| 2.83 | 46.368 | 26.08 | 3.48 | 58.488 | 16.53 |   |       |       |
| 2.84 | 46.573 | 26.07 | 3.49 | 58.674 | 16.47 |   |       |       |

APPENDIX D

Prandtl Meyer functions ( $\gamma = 1.4$ )

| M    | $\nu$   | $\mu$ | M    | $\nu$  | $\mu$ | M | $\nu$ | $\mu$ |
|------|---------|-------|------|--------|-------|---|-------|-------|
| 1.00 | 0       | 90.00 | 1.60 | 14.861 | 38.68 |   |       |       |
| 1.01 | 0.04473 | 81.93 | 1.61 | 15.156 | 38.40 |   |       |       |
| 1.02 | 0.1257  | 78.64 | 1.62 | 15.452 | 38.12 |   |       |       |
| 1.03 | 0.2294  | 76.14 | 1.63 | 15.747 | 37.84 |   |       |       |
| 1.04 | 0.3510  | 74.06 | 1.64 | 16.043 | 37.57 |   |       |       |
| 1.05 | 0.4874  | 72.25 | 1.65 | 16.338 | 37.31 |   |       |       |
| 1.06 | 0.6367  | 70.63 | 1.66 | 16.633 | 37.04 |   |       |       |
| 1.07 | 0.7973  | 69.16 | 1.67 | 16.928 | 36.78 |   |       |       |
| 1.08 | 0.9690  | 67.81 | 1.68 | 17.222 | 36.53 |   |       |       |
| 1.09 | 1.148   | 66.55 | 1.69 | 17.516 | 36.28 |   |       |       |
| 1.10 | 1.336   | 65.38 | 1.70 | 17.810 | 36.03 |   |       |       |
| 1.11 | 1.532   | 64.28 | 1.71 | 18.103 | 35.79 |   |       |       |
| 1.12 | 1.735   | 63.23 | 1.72 | 18.397 | 35.55 |   |       |       |
| 1.13 | 1.944   | 62.25 | 1.73 | 18.689 | 35.31 |   |       |       |
| 1.14 | 2.160   | 61.31 | 1.74 | 18.981 | 35.08 |   |       |       |
| 1.15 | 2.381   | 60.41 | 1.75 | 19.273 | 34.85 |   |       |       |
| 1.16 | 2.607   | 59.55 | 1.76 | 19.565 | 34.62 |   |       |       |
| 1.17 | 2.839   | 58.73 | 1.77 | 19.855 | 34.40 |   |       |       |
| 1.18 | 3.074   | 57.94 | 1.78 | 20.146 | 34.18 |   |       |       |
| 1.19 | 3.314   | 57.18 | 1.79 | 20.436 | 33.96 |   |       |       |
| 1.20 | 3.558   | 56.44 | 1.80 | 20.725 | 33.75 |   |       |       |
| 1.21 | 3.806   | 55.74 | 1.81 | 21.014 | 33.54 |   |       |       |
| 1.22 | 4.057   | 55.05 | 1.82 | 21.302 | 33.33 |   |       |       |
| 1.23 | 4.312   | 54.39 | 1.83 | 21.590 | 33.12 |   |       |       |
| 1.24 | 4.569   | 53.75 | 1.84 | 21.877 | 32.92 |   |       |       |
| 1.25 | 4.830   | 53.13 | 1.85 | 22.163 | 32.72 |   |       |       |
| 1.26 | 5.093   | 52.53 | 1.86 | 22.449 | 32.52 |   |       |       |
| 1.27 | 5.359   | 51.94 | 1.87 | 22.735 | 32.33 |   |       |       |
| 1.28 | 5.627   | 51.38 | 1.88 | 23.019 | 32.13 |   |       |       |
| 1.29 | 5.896   | 50.82 | 1.89 | 23.303 | 31.94 |   |       |       |
| 1.30 | 6.170   | 50.28 | 1.90 | 23.586 | 31.76 |   |       |       |
| 1.31 | 6.445   | 49.76 | 1.91 | 23.869 | 31.57 |   |       |       |
| 1.32 | 6.721   | 49.25 | 1.92 | 24.151 | 31.39 |   |       |       |
| 1.33 | 7.000   | 48.75 | 1.93 | 24.432 | 31.21 |   |       |       |
| 1.34 | 7.280   | 48.27 | 1.94 | 24.712 | 31.03 |   |       |       |
| 1.35 | 7.561   | 47.79 | 1.95 | 24.992 | 30.85 |   |       |       |
| 1.36 | 7.844   | 47.33 | 1.96 | 25.271 | 30.68 |   |       |       |
| 1.37 | 8.129   | 46.88 | 1.97 | 25.549 | 30.51 |   |       |       |
| 1.38 | 8.415   | 46.44 | 1.98 | 25.827 | 30.33 |   |       |       |
| 1.39 | 8.699   | 46.01 | 1.99 | 26.104 | 30.17 |   |       |       |
| 1.40 | 8.987   | 45.58 | 2.00 | 26.380 | 30.00 |   |       |       |
| 1.41 | 9.276   | 45.17 | 2.01 | 26.655 | 29.84 |   |       |       |
| 1.42 | 9.565   | 44.77 | 2.02 | 26.929 | 29.67 |   |       |       |
| 1.43 | 9.855   | 44.37 | 2.03 | 27.203 | 29.51 |   |       |       |
| 1.44 | 10.146  | 43.98 | 2.04 | 27.476 | 29.35 |   |       |       |
| 1.45 | 10.438  | 43.60 | 2.05 | 27.748 | 29.20 |   |       |       |
| 1.46 | 10.731  | 43.23 | 2.06 | 28.020 | 29.04 |   |       |       |
| 1.47 | 11.023  | 42.86 | 2.07 | 28.290 | 28.89 |   |       |       |
| 1.48 | 11.317  | 42.51 | 2.08 | 28.560 | 28.74 |   |       |       |
| 1.49 | 11.611  | 42.16 | 2.09 | 28.829 | 28.59 |   |       |       |
| 1.50 | 11.905  | 41.81 | 2.10 | 29.097 | 28.44 |   |       |       |
| 1.51 | 12.200  | 41.47 | 2.11 | 29.364 | 28.29 |   |       |       |
| 1.52 | 12.495  | 41.14 | 2.12 | 29.631 | 28.14 |   |       |       |
| 1.53 | 12.790  | 40.81 | 2.13 | 29.897 | 28.00 |   |       |       |
| 1.54 | 13.086  | 40.49 | 2.14 | 30.161 | 27.86 |   |       |       |
| 1.55 | 13.381  | 40.18 | 2.15 | 30.425 | 27.72 |   |       |       |
| 1.56 | 13.677  | 39.87 | 2.16 | 30.689 | 27.58 |   |       |       |
| 1.57 | 13.973  | 39.56 | 2.17 | 30.951 | 27.44 |   |       |       |
| 1.58 | 14.269  | 39.27 | 2.18 | 31.212 | 27.30 |   |       |       |
| 1.59 | 14.564  | 38.97 | 2.19 | 31.473 | 27.17 |   |       |       |

**APPENDIX D (continued)**

Prandtl Meyer functions ( $\gamma = 1.4$ )

| M    | v      | $\mu$ | M    | v      | $\mu$ |
|------|--------|-------|------|--------|-------|
| 4.80 | 74.986 | 12.03 | 4.90 | 75.969 | 11.78 |
| 4.81 | 75.046 | 12.00 | 4.91 | 76.066 | 11.76 |
| 4.82 | 75.106 | 11.97 | 4.92 | 76.162 | 11.73 |
| 4.83 | 75.165 | 11.95 | 4.93 | 76.258 | 11.70 |
| 4.84 | 75.225 | 11.92 | 4.94 | 76.353 | 11.68 |
| 4.85 | 75.285 | 11.90 | 4.95 | 76.449 | 11.66 |
| 4.86 | 75.345 | 11.87 | 4.96 | 76.544 | 11.63 |
| 4.87 | 75.405 | 11.85 | 4.97 | 76.638 | 11.61 |
| 4.88 | 75.465 | 11.83 | 4.98 | 76.732 | 11.58 |
| 4.89 | 75.525 | 11.80 | 4.99 | 76.826 | 11.56 |
|      |        |       | 5.00 | 76.920 | 11.54 |

Material in Appendix D is from NACA Report 1135, "Equations, Tables, and Charts for Compressible Flow," Ames Research Staff, 1953.

**APPENDIX E**

Fanno line flow ( $\gamma = 1.4$ )

| M    | T/T*   | p/p*     | p <sub>1</sub> /p <sub>1</sub> * | V/V*   | $f_{max}/D$ |
|------|--------|----------|----------------------------------|--------|-------------|
| 0    | 1.2000 | $\infty$ | $\infty$                         | 0      | $\infty$    |
| 0.01 | 1.2000 | 109.544  | 57.874                           | .01095 | 7134.40     |
| .02  | 1.1999 | 54.770   | 28.942                           | .02191 | 1778.45     |
| .03  | 1.1998 | 36.511   | 19.300                           | .03286 | 787.08      |
| .04  | 1.1996 | 27.382   | 14.482                           | .04381 | 440.35      |
| .05  | 1.1994 | 21.903   | 11.5914                          | .05476 | 280.02      |
| .06  | 1.1991 | 18.251   | 9.6659                           | .06570 | 193.03      |
| .07  | 1.1988 | 15.642   | 8.2915                           | .07664 | 140.66      |
| .08  | 1.1985 | 13.684   | 7.2616                           | .08758 | 106.72      |
| .09  | 1.1981 | 12.162   | 6.4614                           | .09851 | 83.496      |
| .10  | 1.1976 | 10.9435  | 5.8218                           | .10943 | 66.922      |
| .11  | 1.1971 | 9.9465   | 5.2992                           | .12035 | 54.688      |
| .12  | 1.1966 | 9.1156   | 4.8643                           | .13126 | 45.408      |
| .13  | 1.1960 | 8.4123   | 4.4968                           | .14216 | 38.207      |
| .14  | 1.1953 | 7.8093   | 4.1824                           | .15306 | 32.511      |
| .15  | 1.1946 | 7.2866   | 3.9103                           | .16395 | 27.932      |
| .16  | 1.1939 | 6.8291   | 3.6727                           | .17482 | 24.198      |
| .17  | 1.1931 | 6.4252   | 3.4635                           | .18568 | 21.115      |
| .18  | 1.1923 | 6.0662   | 3.2779                           | .19654 | 18.543      |
| .19  | 1.1914 | 5.7448   | 3.1145                           | .20739 | 16.375      |
| .20  | 1.1905 | 5.4555   | 2.9635                           | .21822 | 14.533      |
| .21  | 1.1895 | 5.1936   | 2.8293                           | .22904 | 12.956      |
| .22  | 1.1885 | 4.9554   | 2.7076                           | .23984 | 11.596      |
| .23  | 1.1874 | 4.7378   | 2.5968                           | .25063 | 10.416      |
| .24  | 1.1863 | 4.5383   | 2.4956                           | .26141 | 9.3865      |
| .25  | 1.1852 | 4.3546   | 2.4027                           | .27217 | 8.4834      |
| .26  | 1.1840 | 4.1850   | 2.3173                           | .28291 | 7.6876      |
| .27  | 1.1828 | 4.0280   | 2.2385                           | .29364 | 6.9852      |
| .28  | 1.1815 | 3.8820   | 2.1656                           | .30435 | 6.3572      |
| .29  | 1.1802 | 3.7460   | 2.0979                           | .31504 | 5.7989      |

**APPENDIX D (continued)**

Prandtl Meyer functions ( $\gamma = 1.4$ )

| M    | v      | $\mu$ | M    | v      | $\mu$ |
|------|--------|-------|------|--------|-------|
| 3.50 | 58.530 | 16.60 | 4.15 | 67.713 | 13.94 |
| 3.51 | 58.689 | 16.55 | 4.16 | 67.838 | 13.91 |
| 3.52 | 58.847 | 16.51 | 4.17 | 67.963 | 13.88 |
| 3.53 | 59.004 | 16.46 | 4.18 | 68.087 | 13.84 |
| 3.54 | 59.162 | 16.41 | 4.19 | 68.210 | 13.81 |
| 3.55 | 59.318 | 16.36 | 4.20 | 68.333 | 13.77 |
| 3.56 | 59.474 | 16.31 | 4.21 | 68.456 | 13.74 |
| 3.57 | 59.629 | 16.27 | 4.22 | 68.578 | 13.71 |
| 3.58 | 59.784 | 16.22 | 4.23 | 68.700 | 13.67 |
| 3.59 | 59.938 | 16.17 | 4.24 | 68.821 | 13.64 |
| 3.60 | 60.091 | 16.13 | 4.25 | 68.942 | 13.61 |
| 3.61 | 60.244 | 16.08 | 4.26 | 69.063 | 13.58 |
| 3.62 | 60.397 | 16.04 | 4.27 | 69.183 | 13.54 |
| 3.63 | 60.549 | 15.99 | 4.28 | 69.302 | 13.51 |
| 3.64 | 60.700 | 15.95 | 4.29 | 69.422 | 13.48 |
| 3.65 | 60.851 | 15.90 | 4.30 | 69.541 | 13.45 |
| 3.66 | 61.000 | 15.86 | 4.31 | 69.659 | 13.42 |
| 3.67 | 61.150 | 15.81 | 4.32 | 69.777 | 13.38 |
| 3.68 | 61.299 | 15.77 | 4.33 | 69.895 | 13.35 |
| 3.69 | 61.447 | 15.72 | 4.34 | 70.012 | 13.32 |
| 3.70 | 61.595 | 15.68 | 4.35 | 70.128 | 13.29 |
| 3.71 | 61.743 | 15.64 | 4.36 | 70.245 | 13.26 |
| 3.72 | 61.889 | 15.59 | 4.37 | 70.361 | 13.23 |
| 3.73 | 62.036 | 15.55 | 4.38 | 70.476 | 13.20 |
| 3.74 | 62.181 | 15.51 | 4.39 | 70.591 | 13.17 |
| 3.75 | 62.326 | 15.47 | 4.40 | 70.706 | 13.14 |
| 3.76 | 62.471 | 15.42 | 4.41 | 70.820 | 13.11 |
| 3.77 | 62.615 | 15.38 | 4.42 | 70.934 | 13.08 |
| 3.78 | 62.758 | 15.34 | 4.43 | 71.048 | 13.05 |
| 3.79 | 62.901 | 15.30 | 4.44 | 71.161 | 13.02 |
| 3.80 | 63.044 | 15.26 | 4.45 | 71.274 | 12.99 |
| 3.81 | 63.186 | 15.22 | 4.46 | 71.386 | 12.96 |
| 3.82 | 63.327 | 15.18 | 4.47 | 71.498 | 12.93 |
| 3.83 | 63.468 | 15.14 | 4.48 | 71.609 | 12.90 |
| 3.84 | 63.608 | 15.10 | 4.49 | 71.721 | 12.87 |
| 3.85 | 63.748 | 15.06 | 4.50 | 71.832 | 12.84 |
| 3.86 | 63.887 | 15.02 | 4.51 | 71.942 | 12.81 |
| 3.87 | 64.026 | 14.98 | 4.52 | 72.052 | 12.78 |
| 3.88 | 64.164 | 14.94 | 4.53 | 72.162 | 12.75 |
| 3.89 | 64.302 | 14.90 | 4.54 | 72.271 | 12.72 |
| 3.90 | 64.440 | 14.86 | 4.55 | 72.380 | 12.70 |
| 3.91 | 64.576 | 14.82 | 4.56 | 72.489 | 12.67 |
| 3.92 | 64.713 | 14.78 | 4.57 | 72.597 | 12.64 |
| 3.93 | 64.848 | 14.74 | 4.58 | 72.705 | 12.61 |
| 3.94 | 64.983 | 14.70 | 4.59 | 72.812 | 12.58 |
| 3.95 | 65.118 | 14.67 | 4.60 | 72.919 | 12.56 |
| 3.96 | 65.253 | 14.63 | 4.61 | 73.026 | 12.53 |
| 3.97 | 65.386 | 14.59 | 4.62 | 73.132 | 12.50 |
| 3.98 | 65.520 | 14.55 | 4.63 | 73.238 | 12.47 |
| 3.99 | 65.652 | 14.52 | 4.64 | 73.344 | 12.45 |
| 4.00 | 65.785 | 14.48 | 4.65 | 73.446 | 12.42 |
| 4.01 | 65.917 | 14.44 | 4.66 | 73.548 | 12.39 |
| 4.02 | 66.048 | 14.40 | 4.67 | 73.650 | 12.37 |
| 4.03 | 66.179 | 14.37 | 4.68 | 73.753 | 12.34 |
| 4.04 | 66.309 | 14.33 | 4.69 | 73.857 | 12.31 |
| 4.05 | 66.439 | 14.30 | 4.70 | 73.970 | 12.28 |
| 4.06 | 66.569 | 14.26 | 4.71 | 74.073 | 12.26 |
| 4.07 | 66.698 | 14.22 | 4.72 | 74.176 | 12.23 |
| 4.08 | 66.826 | 14.19 | 4.73 | 74.279 | 12.21 |
| 4.09 | 66.954 | 14.15 | 4.74 | 74.381 | 12.18 |
| 4.10 | 67.082 | 14.12 | 4.75 | 74.483 | 12.15 |
| 4.11 | 67.209 | 14.08 | 4.76 | 74.584 | 12.13 |
| 4.12 | 67.336 | 14.05 | 4.77 | 74.685 | 12.10 |
| 4.13 | 67.462 | 14.01 | 4.78 | 74.786 | 12.08 |
| 4.14 | 67.588 | 13.98 | 4.79 | 74.886 | 12.05 |