

# Compressibility of Gaseous Propane-propene Mixtures

KUN LI and LAWRENCE N. CANJAR

Carnegie Institute of Technology, Pittsburgh, Pennsylvania

The compositions of the coexisting phases of the propane-propene system at five temperatures between 10° and 190°F. were investigated by Reamer and Sage (1). They also determined the molal volumes of the two propane-propene mixtures (0.3711 and 0.7589 mole fractions of propane) at seven temperatures between 10° and 400°F. for pressures from 200 to 10,000 lb./sq. in. abs. However, a more complete knowledge of the volumetric behavior of a binary system requires data throughout the entire range of composition and over extended temperature and pressure ranges. With this end in view, the compressibilities of four gaseous propane-propene mixtures were measured at temperatures from 212° to 482°F. at 45°F. intervals and at pressures from 200 to 3,200 lb./sq. in. abs. The mixtures were 0.1962, 0.4386, 0.5814, and 0.8131 mole fractions of propane. To supplement the measurements, three isotherms (212°, 302°, and 437°F.) of a fifth mixture (0.1655 mole fraction propane) were also determined at pressures up to 3,200 lb./sq. in. abs.

## APPARATUS

The apparatus and experimental technique used in this work have been previously described (2). The samples of pure hydrocarbons were Phillips Petroleum Company research-grade hydrocarbons. The purities were stated as follows: propane, 99.99%; propene, 99.70%. The pressure measurement is estimated to be accurate to within  $\pm 0.07\%$ . The maximum uncertainty in volume is 0.4% and in mass of the sample 0.05%. The temperature is known to 0.02°C. Adding all the individual uncertainties gives the over-all maximum un-

certainty in compressibility factor at about 0.52%. At lower pressures, where the volumes of the sample are larger, the over-all uncertainty is much less than 0.52% (approximately 0.12%). The uncertainties reported here are estimated uncertainties in accuracy based on earlier calibration meas-

urements on propane (2) and ethane (7) whose properties are well known.

## EXPERIMENTAL DATA

In Tables 1 to 5 (pages 448 to 450) are presented the smoothed data in terms of

TABLE 1. SMOOTHED COMPRESSIBILITIES OF PROPANE-PROPENE MIXTURES

| Pressure,<br>lb./sq. in. abs. | Mixture 1, mole fraction propane, 0.1962 |                    |                    |                    |                    |                    |                    |
|-------------------------------|------------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                               | Compressibility factor                   |                    |                    |                    |                    |                    |                    |
|                               | 100°C.<br>(212°F.)                       | 125°C.<br>(257°F.) | 150°C.<br>(302°F.) | 175°C.<br>(347°F.) | 200°C.<br>(392°F.) | 225°C.<br>(437°F.) | 250°C.<br>(482°F.) |
| 0                             | 1.000                                    | 1.000              | 1.000              | 1.000              | 1.000              | 1.000              | 1.000              |
| 100                           | 0.953                                    | 0.962              | 0.969              | 0.973              | 0.978              | 0.982              | 0.985              |
| 200                           | 0.898                                    | 0.919              | 0.935              | 0.946              | 0.955              | 0.964              | 0.970              |
| 300                           | 0.835                                    | 0.873              | 0.899              | 0.918              | 0.933              | 0.945              | 0.955              |
| 400                           | 0.768                                    | 0.824              | 0.861              | 0.889              | 0.910              | 0.927              | 0.940              |
| 500                           | 0.695                                    | 0.774              | 0.824              | 0.860              | 0.888              | 0.909              | 0.926              |
| 600                           | 0.595                                    | 0.720              | 0.786              | 0.831              | 0.865              | 0.890              | 0.911              |
| 700                           | 0.432                                    | 0.655              | 0.744              | 0.802              | 0.843              | 0.872              | 0.897              |
| 800                           | 0.268                                    | 0.581              | 0.700              | 0.772              | 0.820              | 0.855              | 0.883              |
| 900                           | 0.258                                    | 0.513              | 0.654              | 0.742              | 0.798              | 0.838              | 0.870              |
| 1,000                         | 0.267                                    | 0.447              | 0.610              | 0.709              | 0.777              | 0.822              | 0.858              |
| 1,100                         | 0.275                                    | 0.405              | 0.572              | 0.679              | 0.756              | 0.807              | 0.846              |
| 1,200                         | 0.302                                    | 0.389              | 0.543              | 0.654              | 0.738              | 0.792              | 0.834              |
| 1,300                         | 0.321                                    | 0.386              | 0.520              | 0.635              | 0.720              | 0.778              | 0.824              |
| 1,400                         | 0.339                                    | 0.390              | 0.503              | 0.619              | 0.704              | 0.766              | 0.814              |
| 1,500                         | 0.358                                    | 0.401              | 0.492              | 0.605              | 0.690              | 0.756              | 0.806              |
| 1,600                         | 0.376                                    | 0.415              | 0.490              | 0.594              | 0.678              | 0.748              | 0.799              |
| 1,700                         | 0.394                                    | 0.430              | 0.493              | 0.586              | 0.670              | 0.740              | 0.793              |
| 1,800                         | 0.413                                    | 0.446              | 0.500              | 0.582              | 0.664              | 0.734              | 0.788              |
| 1,900                         | 0.431                                    | 0.462              | 0.509              | 0.584              | 0.660              | 0.728              | 0.783              |
| 2,000                         | 0.449                                    | 0.477              | 0.519              | 0.587              | 0.659              | 0.725              | 0.780              |
| 2,200                         | 0.486                                    | 0.509              | 0.543              | 0.598              | 0.663              | 0.723              | 0.777              |
| 2,400                         | 0.523                                    | 0.541              | 0.572              | 0.615              | 0.673              | 0.727              | 0.778              |
| 2,600                         | 0.560                                    | 0.574              | 0.600              | 0.636              | 0.688              | 0.735              | 0.783              |
| 2,800                         | 0.597                                    | 0.608              | 0.629              | 0.660              | 0.705              | 0.747              | 0.792              |
| 3,000                         | 0.633                                    | 0.642              | 0.658              | 0.686              | 0.724              | 0.762              | 0.804              |
| 3,200                         | 0.668                                    | 0.676              | 0.689              | 0.714              | 0.744              | 0.779              | 0.817              |

TABLE 2. SMOOTHED COMPRESSIBILITIES OF PROPANE-PROPENE MIXTURES

Mixture 2, mole fraction propane 0.4386

| Pressure,<br>lb./sq. in. abs. | Compressibility factor |                    |                    |                    |                    |                    |                    |
|-------------------------------|------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                               | 100°C.<br>(212°F.)     | 125°C.<br>(257°F.) | 150°C.<br>(302°F.) | 175°C.<br>(347°F.) | 200°C.<br>(392°F.) | 225°C.<br>(437°F.) | 250°C.<br>(482°F.) |
| 0                             | 1.000                  | 1.000              | 1.000              | 1.000              | 1.000              | 1.000              | 1.000              |
| 100                           | 0.954                  | 0.963              | 0.968              | 0.972              | 0.976              | 0.980              | 0.984              |
| 200                           | 0.899                  | 0.920              | 0.933              | 0.943              | 0.953              | 0.961              | 0.968              |
| 300                           | 0.835                  | 0.870              | 0.896              | 0.914              | 0.929              | 0.942              | 0.953              |
| 400                           | 0.765                  | 0.819              | 0.857              | 0.884              | 0.906              | 0.923              | 0.938              |
| 500                           | 0.685                  | 0.765              | 0.817              | 0.854              | 0.882              | 0.904              | 0.922              |
| 600                           | 0.573                  | 0.706              | 0.776              | 0.824              | 0.858              | 0.885              | 0.908              |
| 700                           | 0.372                  | 0.640              | 0.734              | 0.793              | 0.835              | 0.867              | 0.893              |
| 800                           |                        | 0.568              | 0.689              | 0.762              | 0.812              | 0.849              | 0.879              |
| 900                           |                        | 0.490              | 0.643              | 0.732              | 0.788              | 0.832              | 0.865              |
| 1,000                         |                        | 0.427              | 0.599              | 0.702              | 0.766              | 0.815              | 0.852              |
| 1,100                         |                        |                    | 0.561              | 0.672              | 0.745              | 0.798              | 0.838              |
| 1,200                         |                        |                    | 0.532              | 0.646              | 0.726              | 0.783              | 0.827              |
| 1,300                         |                        |                    | 0.508              | 0.624              | 0.708              | 0.770              | 0.816              |
| 1,400                         |                        |                    | 0.490              | 0.606              | 0.692              | 0.757              | 0.806              |
| 1,500                         |                        |                    | 0.482              | 0.590              | 0.678              | 0.747              | 0.797              |
| 1,600                         |                        |                    | 0.481              | 0.581              | 0.668              | 0.738              | 0.789              |
| 1,700                         |                        |                    | 0.486              | 0.576              | 0.660              | 0.730              | 0.782              |
| 1,800                         |                        |                    | 0.495              | 0.574              | 0.654              | 0.725              | 0.776              |
| 1,900                         |                        |                    | 0.506              | 0.576              | 0.652              | 0.720              | 0.772              |
| 2,000                         |                        |                    | 0.517              | 0.583              | 0.653              | 0.718              | 0.770              |
| 2,200                         |                        |                    |                    |                    |                    | 0.718              | 0.768              |
| 2,400                         |                        |                    |                    |                    |                    | 0.723              | 0.772              |
| 2,600                         |                        |                    |                    |                    |                    | 0.733              | 0.779              |
| 2,800                         |                        |                    |                    |                    |                    | 0.746              | 0.788              |
| 3,000                         |                        |                    |                    |                    |                    | 0.760              | 0.799              |
| 3,200                         |                        |                    |                    |                    |                    | 0.776              | 0.810              |

TABLE 3. SMOOTHED COMPRESSIBILITIES OF PROPANE-PROPENE MIXTURES

Mixture 3, mole fraction propane 0.5814

| Pressure,<br>lb./sq. in. abs. | Compressibility factor |                    |                    |                    |                    |                    |                    |
|-------------------------------|------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|                               | 100°C.<br>(212°F.)     | 125°C.<br>(257°F.) | 150°C.<br>(302°F.) | 175°C.<br>(347°F.) | 200°C.<br>(392°F.) | 225°C.<br>(437°F.) | 250°C.<br>(482°F.) |
| 0                             | 1.000                  | 1.000              | 1.000              | 1.000              | 1.000              | 1.000              | 1.000              |
| 100                           | 0.949                  | 0.959              | 0.965              | 0.971              | 0.976              | 0.980              | 0.984              |
| 200                           | 0.889                  | 0.913              | 0.929              | 0.942              | 0.952              | 0.960              | 0.967              |
| 300                           | 0.824                  | 0.864              | 0.891              | 0.913              | 0.928              | 0.941              | 0.952              |
| 400                           | 0.754                  | 0.813              | 0.853              | 0.883              | 0.905              | 0.922              | 0.936              |
| 500                           | 0.669                  | 0.760              | 0.813              | 0.853              | 0.881              | 0.903              | 0.920              |
| 600                           | 0.557                  | 0.700              | 0.772              | 0.822              | 0.857              | 0.884              | 0.906              |
| 700                           | 0.270                  | 0.632              | 0.729              | 0.789              | 0.832              | 0.865              | 0.891              |
| 800                           | 0.244                  | 0.557              | 0.683              | 0.757              | 0.807              | 0.848              | 0.877              |
| 900                           | 0.254                  | 0.482              | 0.637              | 0.726              | 0.782              | 0.831              | 0.863              |
| 1,000                         | 0.272                  | 0.416              | 0.592              | 0.695              | 0.760              | 0.814              | 0.850              |
| 1,100                         | 0.289                  | 0.385              | 0.546              | 0.668              | 0.739              | 0.799              | 0.838              |
| 1,200                         | 0.306                  | 0.377              | 0.513              | 0.643              | 0.720              | 0.784              | 0.826              |
| 1,300                         | 0.324                  | 0.378              | 0.496              | 0.622              | 0.704              | 0.770              | 0.816              |
| 1,400                         | 0.342                  | 0.386              | 0.487              | 0.606              | 0.690              | 0.758              | 0.806              |
| 1,500                         | 0.361                  | 0.399              | 0.484              | 0.594              | 0.678              | 0.746              | 0.797              |
| 1,600                         | 0.379                  | 0.414              | 0.485              | 0.587              | 0.668              | 0.737              | 0.789              |
| 1,700                         | 0.398                  | 0.430              | 0.490              | 0.583              | 0.659              | 0.730              | 0.782              |
| 1,800                         | 0.416                  | 0.446              | 0.498              | 0.582              | 0.654              | 0.723              | 0.776              |
| 1,900                         | 0.434                  | 0.462              | 0.507              | 0.582              | 0.650              | 0.718              | 0.772              |
| 2,000                         | 0.453                  | 0.478              | 0.517              | 0.586              | 0.650              | 0.716              | 0.769              |
| 2,200                         | 0.490                  | 0.511              | 0.544              | 0.597              | 0.656              | 0.715              | 0.770              |
| 2,400                         | 0.527                  | 0.544              | 0.572              | 0.615              | 0.668              | 0.720              | 0.775              |
| 2,600                         | 0.564                  | 0.579              | 0.602              | 0.637              | 0.683              | 0.731              | 0.782              |
| 2,800                         | 0.602                  | 0.614              | 0.634              | 0.662              | 0.702              | 0.746              | 0.791              |
| 3,000                         | 0.638                  | 0.649              | 0.667              | 0.689              | 0.722              | 0.763              | 0.801              |
| 3,200                         | 0.676                  | 0.685              | 0.702              | 0.718              | 0.745              | 0.782              | 0.812              |

compressibility factor,  $Z = MPV/mRT$ , in which  $M$  is the molecular weight of the mixture,  $m$  the mass of the sample,  $V$  the volume of the sample,  $P$  the pressure,  $T$  the absolute temperature, and  $R$  the gas constant. In the computation of compressibility factors the values 44.094 and 42.078 were used for the molecular weight of propane and propene respectively. ( $H = 1.008$ ;  $C = 12.010$ .) The gas constant was 82.0567 cm. atm./( $^{\circ}$ K.)(g.-mole). Actual experimental data are given in Tables 7 through 11.\*

It was found that at all seven temperatures at which compressibility data were measured the data presented here extrapolate nicely to the limiting values representing the compressibilities of pure components. For the compressibilities of pure propane, the data of Reamer, Sage, and Lacey (3) and of Beattie, Kay, and Kaminsky (4) were used. The compressibilities of pure propene were taken from the results of Farrington and Sage (5) and Marchman, Prengle, and Motard (6). It may be of interest to point out that wherever a discrepancy exists in the compressibilities of pure propene, the results of this work give better agreement with that of Marchman, Prengle, and Motard (6) than that of Farrington and Sage (5). Of course, this is to be expected since the same apparatus was used by Marchman et al. and the present authors.

In order to compare the present data on propane-propene mixture with the results of Reamer and Sage (1), the present data were interpolated graphically with respect to pressure and composition, and the data of Reamer and Sage were interpolated according to temperature. As shown in Table 6, in spite of additional uncertainties introduced by interpolation the agreement between the data of this work and those of Reamer and Sage (1) is satisfactory and is, in most cases, well within the experimental uncertainties.

## LITERATURE CITED

1. Reamer, H. H., and B. H. Sage, *Ind. Eng. Chem.*, **43**, 1628 (1951).
2. Cherney, B. J., Henry Marchman, and Robert York, *Ind. Eng. Chem.*, **41**, 2653 (1949).
3. Reamer, H. H., B. H. Sage, and W. N. Lacey, *Ind. Eng. Chem.*, **41**, 482 (1949).
4. Beattie, J. A., W. C. Kay, and Joseph Kaminsky, *J. Am. Chem. Soc.*, **59**, 1589 (1937).
5. Farrington, P. S., and B. H. Sage, *Ind. Eng. Chem.*, **41**, 1734 (1949).
6. Marchman, Henry, H. W. Prengle, and R. L. Motard, *Ind. Eng. Chem.*, **41**, 2658 (1949).
7. Prengle, H. W., and Henry Marchman, *Ind. Eng. Chem.*, **42**, 2371 (1950).

\*Tabular material (Tables 7-11) has been deposited as document 5049 with the American Documentation Institute, Photoduplication Service, Library of Congress, Washington 25, D. C., and may be obtained for \$1.25 for photoprints or 35-mm. microfilm.

TABLE 4. SMOOTHED COMPRESSIBILITIES OF PROPANE-PROPENE MIXTURES

Mixture 4, mole fraction propane 0.8131

| Pressure,<br>lb./sq. in. abs. | Compressibility factor |                    |                    |                    |                    |
|-------------------------------|------------------------|--------------------|--------------------|--------------------|--------------------|
|                               | 100°C.<br>(212°F.)     | 125°C.<br>(257°F.) | 175°C.<br>(347°F.) | 200°C.<br>(392°F.) | 250°C.<br>(482°F.) |
| 0                             | 1.000                  | 1.000              | 1.000              | 1.000              | 1.000              |
| 100                           | 0.952                  | 0.962              | 0.975              | 0.978              | 0.983              |
| 200                           | 0.892                  | 0.918              | 0.947              | 0.954              | 0.966              |
| 300                           | 0.824                  | 0.866              | 0.918              | 0.930              | 0.950              |
| 400                           | 0.746                  | 0.809              | 0.886              | 0.905              | 0.934              |
| 500                           | 0.660                  | 0.748              | 0.854              | 0.880              | 0.918              |
| 600                           | 0.527                  | 0.683              | 0.820              | 0.855              | 0.903              |
| 700                           | 0.270                  | 0.614              | 0.785              | 0.830              | 0.888              |
| 800                           | 0.249                  | 0.540              | 0.751              | 0.805              | 0.873              |
| 900                           | 0.254                  | 0.453              | 0.718              | 0.780              | 0.858              |
| 1,000                         | 0.268                  | 0.387              | 0.686              | 0.758              | 0.844              |
| 1,100                         | 0.268                  | 0.366              | 0.656              | 0.736              | 0.831              |
| 1,200                         | 0.304                  | 0.366              | 0.630              | 0.716              | 0.819              |
| 1,300                         | 0.324                  | 0.375              | 0.608              | 0.698              | 0.808              |
| 1,400                         | 0.344                  | 0.387              | 0.590              | 0.682              | 0.798              |
| 1,500                         | 0.363                  | 0.400              | 0.577              | 0.669              | 0.789              |
| 1,600                         | 0.383                  | 0.414              | 0.569              | 0.658              | 0.781              |
| 1,700                         | 0.403                  | 0.430              | 0.566              | 0.651              | 0.774              |
| 1,800                         | 0.422                  | 0.447              | 0.567              | 0.646              | 0.769              |
| 1,900                         | 0.441                  | 0.464              | 0.572              | 0.644              | 0.766              |
| 2,000                         | 0.460                  | 0.481              | 0.578              | 0.645              | 0.764              |
| 2,200                         | 0.498                  | 0.516              | 0.595              | 0.652              | 0.764              |
| 2,400                         | 0.536                  | 0.550              | 0.616              | 0.665              | 0.769              |
| 2,600                         | 0.573                  | 0.584              | 0.640              | 0.682              | 0.777              |
| 2,800                         | 0.611                  | 0.618              | 0.666              | 0.703              | 0.788              |
| 3,000                         | 0.648                  | 0.653              | 0.694              | 0.726              | 0.800              |
| 3,200                         | 0.684                  | 0.688              | 0.722              | 0.748              | 0.814              |

TABLE 5. SMOOTHED COMPRESSIBILITIES OF PROPANE-PROPENE MIXTURES

Mixture 5, mole fraction propane 0.1655

| Pressure,<br>lb./sq. in. abs. | Compressibility factor |                    |                    |
|-------------------------------|------------------------|--------------------|--------------------|
|                               | 100°C.<br>(212°F.)     | 150°C.<br>(302°F.) | 225°C.<br>(437°F.) |
| 0                             | 1.000                  | 1.000              | 1.000              |
| 100                           | 0.950                  | 0.968              | 0.982              |
| 200                           | 0.895                  | 0.935              | 0.964              |
| 300                           | 0.836                  | 0.900              | 0.946              |
| 400                           | 0.772                  | 0.863              | 0.928              |
| 500                           | 0.695                  | 0.826              | 0.910              |
| 600                           | 0.601                  | 0.787              | 0.893              |
| 700                           | 0.458                  | 0.747              | 0.875              |
| 800                           | 0.271                  | 0.705              | 0.858              |
| 900                           | 0.258                  | 0.664              | 0.841              |
| 1,000                         | 0.266                  | 0.621              | 0.824              |
| 1,100                         | 0.281                  | 0.578              | 0.808              |
| 1,200                         | 0.299                  | 0.545              | 0.794              |
| 1,300                         | 0.318                  | 0.521              | 0.780              |
| 1,400                         | 0.336                  | 0.504              | 0.768              |
| 1,500                         | 0.355                  | 0.494              | 0.758              |
| 1,600                         | 0.373                  | 0.492              | 0.748              |
| 1,700                         | 0.391                  | 0.495              | 0.740              |
| 1,800                         | 0.409                  | 0.501              | 0.734              |
| 1,900                         | 0.426                  | 0.510              | 0.728              |
| 2,000                         | 0.444                  | 0.519              | 0.725              |
| 2,200                         | 0.480                  | 0.541              | 0.722              |
| 2,400                         | 0.516                  | 0.568              | 0.725              |
| 2,600                         | 0.551                  | 0.595              | 0.733              |
| 2,800                         | 0.587                  | 0.624              | 0.746              |
| 3,000                         | 0.622                  | 0.652              | 0.763              |
| 3,200                         | 0.658                  | 0.682              | 0.783              |

TABLE 6. COMPARISON OF DATA ON PROPANE-PROPENE MIXTURES

| Compressibility factor                    |           |       |
|-------------------------------------------|-----------|-------|
| 257°F.                                    |           |       |
| P, lb./sq. in. abs.                       | This work | (1)   |
| Mixture: mole fraction propane 0.7589 (1) |           |       |
| 400                                       | 0.810     | 0.809 |
| 1,000                                     | 0.409     | 0.416 |
| 1,500                                     | 0.400     | 0.405 |
| 2,500                                     | 0.565     | 0.567 |
| 3,000                                     | 0.656     | 0.654 |
| Mixture: mole fraction propane 0.3711 (1) |           |       |
| 400                                       | 0.821     | 0.820 |
| 1,000                                     | 0.433     | 0.443 |
| 1,500                                     | 0.400     | 0.405 |
| 2,500                                     | 0.559     | 0.555 |
| 3,000                                     | 0.643     | 0.641 |
| 302°F.                                    |           |       |
| P, lb./sq. in. abs.                       | This work | (1)   |
| Mixture: mole fraction propane 0.7589 (1) |           |       |
| 400                                       | 0.848     | 0.850 |
| 1,000                                     | 0.572     | 0.570 |
| 1,500                                     | 0.477     | 0.473 |
| 2,500                                     | 0.591     | 0.593 |
| 3,000                                     | 0.670     | 0.669 |
| Mixture: mole fraction propane 0.3711 (1) |           |       |
| 400                                       | 0.860     | 0.860 |
| 1,000                                     | 0.603     | 0.601 |
| 1,500                                     | 0.487     | 0.482 |
| 2,500                                     | 0.585     | 0.585 |
| 3,000                                     | 0.662     | 0.658 |
| 347°F.                                    |           |       |
| P, lb./sq. in. abs.                       | This work | (1)   |
| Mixture: mole fraction propane 0.7589 (1) |           |       |
| 400                                       | 0.879     | 0.880 |
| 1,000                                     | 0.687     | 0.686 |
| 1,500                                     |           |       |
| 2,500                                     | 0.629     | 0.630 |
| 3,000                                     | 0.692     | 0.693 |
| Mixture: mole fraction propane 0.3711 (1) |           |       |
| 400                                       | 0.886     | 0.887 |
| 1,000                                     | 0.705     | 0.702 |
| 1,500                                     |           |       |
| 2,500                                     | 0.627     | 0.625 |
| 3,000                                     | 0.687     | 0.685 |
| 392°F.                                    |           |       |
| P, lb./sq. in. abs.                       | This work | (1)   |
| Mixture: mole fraction propane 0.7589 (1) |           |       |
| 400                                       | 0.903     | 0.902 |
| 1,000                                     | 0.758     | 0.755 |
| 1,500                                     | 0.670     | 0.667 |
| 2,500                                     |           |       |
| 3,000                                     | 0.723     | 0.724 |
| Mixture: mole fraction propane 0.3711 (1) |           |       |
| 400                                       | 0.907     | 0.908 |
| 1,000                                     | 0.769     | 0.769 |
| 1,500                                     | 0.685     | 0.680 |
| 2,500                                     |           |       |
| 3,000                                     | 0.718     | 0.718 |