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Horizontal Convective Boiling of R1234yf, R134a, and R450A within a Micro-Fin Tube; Extensive Measurement and Analysis

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Horizontal Convective Boiling of R1234yf, R134a, and R450A within a Micro-Fin Tube; Extensive Measurement and Analysis

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ABSTRACT
This report presents local convective boiling heat transfer and Fanning friction factor measurements in a micro-fin tube for R134a and two possible low global warming potential (GWP) refrigerant replacements for R134a: R1234yf and R450A. Test section heating was achieved with water in either counterflow or in parallel flow with the test refrigerant to provide for a range of heat fluxes for each thermodynamic quality. An existing correlation from the literature for single and multi-component mixtures was shown to not satisfactorily predict the convective boiling measurements for flow qualities greater than 40 %. Accordingly, a new correlation was developed specifically for the test fluids of this study so that a fair comparison of the heat transfer performance of the low GWP refrigerants to that of R134a could be made. The new correlation was used to compare the heat transfer coefficient of the three test fluids at the same heat flux, saturated refrigerant temperature, and refrigerant mass flux. The resulting example comparison, for the same operating conditions, showed that the heat transfer coefficient of the multi-component R450A and the single-component R1234yf were, on average, 15 % less and 5 % less, respectively, than that of the single-component R134a. Friction factor measurements were also compared to predictions from an existing correlation. A new correlation for the friction factor was developed to provide a more accurate prediction. The measurements and the new models are important for the evaluation of potential low-GWP refrigerants replacements for R134a.

Keywords: boiling, enhanced heat transfer, low-GWP, micro-fin, refrigerant mixtures

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INTRODUCTION[1]

Evaporators and condensers for new unitary refrigeration and air-conditioning equipment typically use internally enhanced tubes, like the micro-fin tube, to provide improved refrigerant-side, two-phase heat transfer performance. The micro-fin tube is a good choice for unitary equipment because it provides the highest heat transfer with the lowest pressure drop of the commercially available internal enhancements (Webb and Kim, 2005). Consequently, flow boiling heat transfer data for the micro-fin tube with R1234yf and R450A are essential for the evaluation of their use for unitary applications.

Pressure from the policies set by the Montreal Protocol (1987) concerning ozone depletion potential (ODP), and the Kyoto Protocol (1997) and the European Mobile Directive (2006) for global warming potential (GWP) have caused a recent shift to refrigerants with both zero ODP and low GWP. Refrigerant R134a, ubiquitously used for air-conditioning and refrigeration applications, has zero ODP, but a rather large 100-year horizon GWP[2] of 1300 (IPCC, 2013). Two new refrigerants, R1234yf (2,3,3,3-Tetrafluoroprop-1-ene), and R450A (R1234ze/R134a (58/42)), are potential low GWP replacements for R134a having GWPs of <1 (Myhre et al., 2013) and 547 (Honeywell, 2014), respectively.

A significant number of experimental measurement studies of evaporative heat transfer in the micro-fin tubes have been published for R134a. For example, Olivier et al. (2004), Yun et al. (2002), Seo and Kim (2000), Yu et al. (2002), Kim et al. (2002), Hamilton et al. (2008), and Wellsandt and Vamling (2005) have produced experimental data and/or developed models for R134a flow boiling in a variety of micro-fin tube geometries. The purpose of making measurements with R134a in the present study is to establish an evaporative heat transfer performance baseline that can be used to compare to the low GWP replacements, R1234yf and R450A.

The number of experimental measurement studies of evaporative heat transfer in micro-fin tubes for R1234yf is less extensive than that for R134a. Park and Jung (2010) and Saitoh et al. (2011) completed some of the earliest boiling experiments with R1234yf. However, neither of these were for flow boiling in micro-fin tubes. The study by Park and Jung (2010) was for nucleate pool boiling while the one by Saitoh et al. (2011) was for flow boiling in a horizontal smooth tube. Only a few works exist for R1234yf flow boiling in micro-fin tubes. For example, Diani et al. (2015) and Mendoza-Miranda et al. (2015) and have experimentally investigated the heat transfer performance of R1234yf in micro-fin tubes. Diani et al. (2015) made measurements on a single tube and found that they compared well with heat transfer correlations from the literature. Mendoza-Miranda et al. (2015) measured the overall heat transfer performance of a shell-and-tube heat exchanger in an operating refrigerant cycle. They used micro-fin tube correlations from the literature and found that the heat transfer performance of a shell-and-tube heat exchanger with micro-fin tubes could be successfully modeled. Han et al. (2013) and Kedzierski and Park (2013) measured the flow boiling heat transfer characteristics of a R1234yf/lubricant and a R1234yf/R134a mixture, respectively, inside a micro-fin tube.

Currently, there are no published studies for measured flow boiling of R450A in a micro-fin tube. Mendoza-Miranda et al. (2016) recently used a model to predict the overall heat transfer for a shell-and-

[1] Certain trade names and company products are mentioned in the text or identified in an illustration in order to adequately specify the experimental procedure and equipment used. In no case does such an identification imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the products are necessarily the best available for the purpose.

[2] All GWP values are given for zero contribution from climate-carbon feedbacks.

micro-fin tube evaporator with R450A on the micro-fin tube side. Gorgy (2016) presents pool boiling measurements with R450A.

Because of the relatively recent introduction of R1234yf and R450A, the availability of measured heat transfer data in a micro-fin tube in the literature is lacking for these refrigerants. Consequently, the present study provides measured local flow boiling heat transfer measurements for these two low-GWP refrigerants in a micro-fin tube for test conditions that are applicable for air conditioning applications.

EXPERIMENTAL APPARATUS

Figure 1 shows a sketch of the experimental apparatus used to establish and measure convective boiling heat transfer coefficients. The experimental test facility consisted of two main systems: the refrigerant loop and the water loop. The refrigerant flow rate, pressure, and quality were fixed at the inlet to the test section. The water flow rate and the inlet temperature were fixed to establish the overall refrigerant quality change in the test section. The water temperature drop, the tube wall temperature, the refrigerant temperatures, pressures, and pressure drops were measured at several axial locations along the test section. These measurements were used to calculate the local heat-transfer coefficient for the micro-fin tube.

The test section consisted of a pair of 3.34 m long, horizontal tubes connected by a U-bend. A fixed test pressure was maintained by balancing the refrigerant duty between the subcooler, the test section, the preheater and the condensers. A magnetically coupled gear pump delivered the test refrigerant to the entrance of the test section as saturated, near zero quality, liquid. Another magnetically coupled gear pump supplied a steady flow of water to the annulus of the test section. The inlet temperature of the water loop was held constant for each test with a water chilled heat exchanger and variable electric heaters. The refrigerant and water flow rates were controlled by varying the pump speeds using frequency inverters. Redundant flow rate measurements were made with Coriolis flowmeters and with turbine flowmeters for both the refrigerant and water sides.

Figure 2 shows a cross section of the test section with a detail of the micro-fin tube geometry. The test refrigerant flowed inside a micro-fin tube, while distilled water flowed either in parallel flow or counterflow to the refrigerant in the annulus that surrounded the micro-fin tube. Having some tests in parallel flow and others in counterflow (as shown in Fig. 1) produced a broad range of heat fluxes at both low and high flow qualities. The annulus gap was 2.2 mm, and the micro-fin tube wall thickness was 0.3 mm. The micro fin tube had 60, 0.2 mm high fins that rifled down the axis of the tube at a helix angle (α) of 18° with respect to the tube axis. For this geometry, the cross sectional flow area was 60.8 mm^2, giving an equivalent smooth diameter (D_e) of 8.8 mm. The root diameter of the micro-fin tube was 8.91 mm. The inside-surface area per unit length of the tube was estimated to be 44.6 mm. The hydraulic diameter (D_h) was measured with a polar planimeter from a scaled drawing of the tube cross section and determined to be approximately 5.45 mm. The ratio of the inner surface area of the micro fin tube to the surface area of a smooth tube of the same D_e was 1.6.

Figure 3 provides a detailed schematic of the test section. The annulus was constructed by connecting a series of tubes with 14 pairs of stainless steel flanges. This construction permitted the measurement of both the outer micro-fin wall temperature and the water temperature drop as discussed in the following two paragraphs. The design also avoided abrupt discontinuities such as unheated portions of the test section and tube-wall "fins" between thermopile ends.

Figure 3 shows that thermocouple wires pass between 12 of the gasketed flange pairs to measure the refrigerant-tube wall temperature at ten locations on the top, side, and bottom of the tube wall. These locations were separated by 0.6 m on average, and they were located near the intersection of the shell flanges. In addition to these, thermocouples were also mounted next to the pressure taps near the middle of each test section length. The thermocouple junction was soldered to the outside surface and was sanded to a thickness of approximately 0.5 mm. The leads were strapped to a thin non-electrically-conducting epoxy layer on the wall for a distance of 14.3 mm before they passed between a pair of the shell flanges. The wall temperature was corrected for a heat flux dependent fin effect. The correction was typically 0.05 K. Figure 3 also shows that a chain of thermopiles was used to measure the water temperature drop between each flange location. Each thermopile consisted of ten thermocouples in series, with the ten junctions at each end evenly spaced around the circumference of the annulus. Because the upstream junctions of one thermopile and the downstream junctions of another enter the annulus at the same axial location (except at the water inlet and outlet), the junctions of the adjacent piles were alternated around the circumference. A series of Teflon half-rings attached to the inner refrigerant tube centered the tube in the annulus. The half-rings were circumferentially baffled to mix the water flow. Mixing was further ensured by a turbulent water Reynolds number (Kattan et al. 1995).

As shown in Fig. 3, six refrigerant pressure taps along the test section allowed the measurement of the upstream absolute pressure and five pressure drops along the test section. Two sets of two water pressure taps were used to measure the water pressure drop along each tube. Also, a sheathed thermocouple measured the refrigerant temperature at each end of the two refrigerant tubes, with the junction of each centered radially. Only the thermocouple at the inlet of the first tube was used in the calculations. The entire test section was wrapped with 5 cm of foam insulation to minimize heat transfer between the water and the ambient.

MEASUREMENTS

Table 1 shows the expanded measurement uncertainty (*U*) of the various measurements along with the range of each test parameter in this study. The *U* was estimated with the law of propagation of uncertainty. All expanded measurement uncertainties are reported at the 95 % confidence level. The estimates shown in Table 1 are median values of *U* for the correlated data. Saturated refrigerant properties were evaluated at the measured saturation pressure with the REFPROP (Lemmon et al., 2013) equation of state while using refrigerant-vendor proprietary fluid files for R450A. Table 2 shows representative properties that were obtained from REFPROP for the fluids germane to this study. The left side of Table 2 shows properties that were evaluated for the average test conditions of each fluid, while the right side of the table provides properties that were evaluated at 277.6 K.

The convective boiling heat transfer coefficient based on the actual inner surface area ($h_{2\phi}$) was calculated as:

$$h_{2\phi} = \frac{q''}{T_{\mathrm{w}} - T_{\mathrm{s}}} \qquad (1)$$

where the measured wall temperatures (T_{w}) were fitted to their axial position to reduce the uncertainty in the measurement.

Figure 4 shows the estimated expanded uncertainty of the wall temperature fit for all the measurements as a function of thermodynamic quality. The average uncertainty, at the 95 % confidence level, of the fitted wall temperatures for the counterflow and the parallel flow data was approximately 0.42 K and 0.36 K, respectively. The median of the uncertainty in T_w as shown in Table 1 was approximately 0.4 K.

The water temperature (T_f) was determined from the measured temperature change obtained from each thermopile and the inlet water temperature measurement. The water temperature gradient (dT_f/dz) was calculated with second-order finite difference equations using the measured water temperatures and their locations along the tube length z. The water temperature gradients were then fitted with respect to the tube length. As a check on the water temperature gradient calculation, Fig. 5 shows that the measured water temperatures (open circles) typically agreed with the integrated fit of the water temperature gradient (solid line) to within 0.2 K.

The fitted, local, axial water temperature gradient (dT_f/dz), the measured water mass flow rate ($\dot{m}_f$), and the properties of the water were used to calculate the local heat flux (q'') to the micro-fin tube based on the actual inner surface area:

$$q'' = \frac{\dot{m}_f}{p}\left(c_{p_f} \frac{dT_f}{dz} + v_f \frac{dP_f}{dz} \right) \qquad (2)$$

where p is the wetted perimeter of the inside of the micro-fin tube. The specific heat (c_{pf}) and the specific volume (ν_f) of the water were calculated locally as a function of the water temperature. The water pressure gradient (dP_f/dz) was linearly interpolated between the pressure taps to the location of the wall thermocouples. The pressure gradient term was typically less than 3 % of the temperature gradient term. The heat flux obtained by eq. (2) was reduced by the amount of heat lost to the surroundings. The heat loss to the surroundings was obtained by calibration of single phase heat transfer tests and it was based on the temperature difference between the room and the test fluid. Typically, the heat loss correction was less than a 0.1 % of that obtained from eq. (2). Figure 6 plots the relative uncertainty of the heat flux measurement versus the heat flux. As shown in Fig. 6, the uncertainty of the heat flux remains less than 40 % of the measured value, while the average uncertainty for the counterflow and the parallel flow data is approximately 7 % and 20 % of the measured value, respectively.

Figure 7 shows example plots of the local heat flux as calculated from eq. (2) versus thermodynamic quality for both cases when the water and the refrigerant are in counterflow and parallel flow, respectively. Both heat flux profiles are for R134a at an all-liquid Reynolds number (Re) of roughly 4418 and a refrigerant reduced pressure of approximately 0.09, which was evaluated at the exit of the test section. The discontinuity exhibited in the heat flux profiles is due to the change in refrigerant saturation temperature as caused by the adiabatic pressure drop in the bend that is used to transition from the first leg of the test section to the second leg. The decrease in the refrigerant saturation temperature causes an increase in the difference between the water and the refrigerant temperature, which leads to an increase in the local heat flux. For the counterflow case, the heat flux increases from approximately 1 $kW \cdot m^{-2}$ at a quality near zero to approximately 14 $kW \cdot m^{-2}$ at a quality slightly greater than 0.7. The parallel flow case has the opposite slope and a slightly different range of that for counterflow where the heat flux decreases from approximately 12 $kW \cdot m^{-2}$ at a quality near 0.05 to approximately 1 $kW \cdot m^{-2}$ at a quality of approximately 0.82.

The thermodynamic and transport properties were calculated with version 9.1 of REFPROP (Lemmon et al., 2013) while using enthalpy and pressure as inputs. The enthalpy of the refrigerant liquid at the inlet of the test section was calculated from its measured temperature and pressure. The subsequent increase in refrigerant enthalpy along the test section was calculated from the local heat flux and the measured refrigerant mass flow rate. The refrigerant pressures were measured at six pressure taps along the test section. The pressure was linearly interpolated between the taps. The refrigerant exiting the test section was held to approximately 277.6 K while the fluid entering the test section was near zero quality for all of the tests. Considering that the tests were done for quality ranges between near zero and slightly greater than 0.7, the saturation temperature of the test refrigerants decreased from roughly 282.0 K to 277.6 K for most tests due to the pressure drop. Because the temperature glide of R450A was less than 1 K, as shown in Table 2, the variation in saturation temperature during tests was similar to that for the single-component refrigerants R1234yf and R134a.

The local Nusselt number (Nu) was calculated using the hydraulic diameter and the heat transfer coefficient based on the actual inner surface area of the tube as:

$$\mathrm{Nu} = \frac{h_{2\phi} D_h}{k_l} \tag{3}$$

Figure 8 presents the relative uncertainty of the Nu as a function of the thermodynamic quality. The uncertainty of Nu was between roughly 10 % and 40 %. Measurements of Nu with uncertainties greater than 40 % were discarded. The Nu uncertainty is given in the last column of the Appendix A tables. For all qualities, the average uncertainty of Nu for the presented data was approximately 25 % and 29 % for counterflow and parallel flow, respectively. The reported uncertainties are for the individual measurements. Reduction in the uncertainty can be achieved with repeat measurements for the same operating conditions. However, repeat measurements are difficult to obtain due to the chaotic nature of two-phase flow and the many fixed parameters that need to be matched between measurements.

RESULTS

The 756 data points generated in this study for R1234yf, R134a, and R450A are tabulated in Appendix A, which contains the Nusselt and all-liquid Reynolds numbers and other reduced data that are typically used to characterize flow boiling. Appendix B contains the raw data measurements including the heat flux and the wall and water temperatures and locations. The column entitled "flow" provides a "C" or a "P" to indicate that the measurements were made for either counterflow or parallel flow between the refrigerant and water, respectively. All the parameters given in Appendix A and B are defined in the Nomenclature.

The measured local convective boiling Nusselt numbers (Nu) for R134a and R1234yf were compared to the pure-refrigerant (single component) version of the Hamilton et al. (2008) correlation:

$$\mathrm{Nu_p} = 482.18\,\mathrm{Re}^{0.3}\,\mathrm{Pr}^{C_1}\left(\frac{P_s}{P_c}\right)^{C_2}\,\mathrm{Bo}^{C_3}\left(-\log_{10}\frac{P_s}{P_c}\right)^{C_4} M_w^{\;C_5} \tag{4}$$

where

$$C_1 = 0.51x_q$$
$$C_2 = 5.57x_q - 5.21x_q^2$$
$$C_3 = 0.54 - 1.56x_q + 1.42x_q^2$$
$$C_4 = -0.81 + 12.56x_q - 11.00x_q^2$$
$$C_5 = 0.25 - 0.035x_q^2$$

Here, the all-liquid Reynolds number (Re), the Boiling number (Bo), the liquid Prandtl number (Pr), the reduced pressure (P_s/P_c), and the quality (x_q) are all evaluated locally at the saturation temperature. The all-liquid Reynolds number and the Nusselt number are based on the hydraulic diameter (D_h). The Nusselt number is also based on the actual inner surface area of the tube.

Kedzierski and Kang (2016) provide a correction factor for eq. (4) to predict the flow boiling Nusselt Number (Nu) for mixtures of any number of refrigerants. This was done by multiplying the single-component Nusselt Number ($\mathrm{Nu_p}$) by a modifier to predict multi-component mixtures:

$$\mathrm{Nu} = \mathrm{Nu_p}\left(1 - 36.23\left[\frac{T_\mathrm{d} - T_\mathrm{b}}{T_\mathrm{b}}\right]e^{-0.007\,\mathrm{Re}\,\mathrm{Bo}^{0.47}}\right) \tag{5}$$

where T_d and T_b are the dew-point and bubble-point temperatures, respectively, evaluated at the local saturation pressure and overall composition of the mixture. The T_d - T_b difference is commonly called the temperature glide of the mixture. Typically, large temperature glides cause concentration gradients that lead to heat transfer degradations as compared to what would be expected from a single-component prediction model (Kedzierski et al., 1992). Consequently, the bracketed term in eq. (5) that multiplies $\mathrm{Nu_p}$ describes the mixture degradation effect, which is a function of temperature glide, Bo and Re. A single-component refrigerant would have zero temperature glide, which would result in the mixture degradation effect, represented by the bracketed term, being equal to one. Equation (5) was used along with eq. (4) to predict the Nu for R450A.

The flow map of Yu et al. (2002) for micro-fin tubes was used to determine that approximately 68 % of the measurements were in annular or semi-annular flow with the remaining flow being in low quality intermittent flow. Manwell and Bergles (1990) suggest that the reason annular-like flow is a strong characteristic of micro-fin tubes is that the spiraling fins along the tube axis encourage wetting of the upper tube wall.

Figure 9 shows a comparison between the boiling Nusselt numbers predicted with eq. (5) for the micro-fin tube to those measured here for R1234yf, R134a, and R450A. The gray dashed lines of Fig. 9 are multi-use 95 % confidence intervals on the mean prediction, which vary from ± 7 % of the prediction at a Nu of approximately 140 to approximately ± 3 % for Nusselt numbers around 300. Equation (5) predicts approximately 63 % of the measured convective boiling Nusselt numbers for R1234yf, R134a, and R450A in the micro-fin tube to within approximately ± 20 %. All of the R134a measurements are predicted to within 33 % of the measurements while the R1234yf and the R450A predictions are within 50 % of the measurements. Overall, the measurements for qualities less than 40 % are predicted better than those for qualities greater than 40 %. Nearly 70 % of the predictions that lie outside of the ± 20 % overprediction line are for qualities greater than 40 %.

In an effort to obtain a better prediction of the present data set, a more complicated superposition flow boiling model of Daini et al. (2014) for micro-fin tubes was used and is shown in Fig. 10. Figure 10 plots the measurements versus predicted values of the Nusselt number for R1234yf, R134a, and R450A using the same symbols to represent each fluid as was done in Fig. 9. Equation (5) was applied to the Daini et al. (2014) model for R450A refrigerant and it accounted for less than a 4 % adjustment to the prediction. The predictions appear to be more centered about the measurements; however, a smaller percentage (50 %) of the measurements, as compared to the modified Hamilton et al. (2008) correlation (63 %), are predicted to within ± 20 %. For flow qualities less than 40 %, the Hamilton et al. (2008) correlation predicted approximately 94 % of the measurements to within ± 20 %. In contrast, the Daini et al. (2014) model predicts roughly 35 % of the measurements for qualities less than 40 % to within ± 20 %.

Some of the of cause of the 50 % overprediction by the modified Hamilton et al. (2008) correlation for the R1234yf and R450A fluids may be due to a marginally larger uncertainty in the thermodynamic and transport fluid property predictions for these relatively new refrigerants as compared to R134a. For example, a recently developed viscosity correlation for R1234yf by Huber and Assael (2016) gives a viscosity that is approximately 3 % larger than that given by REFPROP (Lemmon et al., 2013) in Table 2 for 277.6 K. However, even if it were assumed that the actual values for the liquid thermal conductivity, the liquid viscosity, and the critical pressure were 20 % less, 10 % less, and 10 % greater than those provided by REFPROP, then the overprediction of the Hamilton et al. (2008) model would be reduced by only approximately 10 %. Consequently, it is believed that it is not likely that errors in property predictions contribute significantly to the heat transfer overprediction.

This notwithstanding, if "corrections" to the property predictions as detailed above are applied to an approximate heat transfer property analysis, the analysis can be used to explain the difference between the R1234yf and R134a heat transfer coefficients. The present measurements show that the heat transfer coefficient for R1234yf is, on average, 5 % less than that for R134a. This difference is confirmed by the convective boiling measurements presented by Diani et al. (2015) for a micro-fin tube where the R1234yf heat transfer coefficient was shown to be approximately 8 % less than that of R134a. However, if the convective property group $k_l^{0.6}(c_{pl}/\mu_l)^{0.4}\rho_l^{0.8}$ is calculated using REFPROP, as recommended by Kedzierski et al. (1992), to gauge the influence of convection for a fluid, the value for R1234yf is approximately 13 % less than that for R134a. For equal values of latent heat of evaporation, the convective property group would give a good indication of the relative values of convective boiling for two fluids. However, as Table 2 shows, the latent heat of evaporation for R1234yf is approximately 18 % less than that for R134a. Based on the fluid properties and the exponent on the Bo in eq. (4), the R1234yf heat transfer coefficient should be approximately 16 % less than that of R134a. For this case, "corrections" to properties could be used to bring the simple heat transfer property analysis and heat transfer measurements into better agreement by reducing the liquid thermal conductivity and increasing the liquid viscosity by approximately 8 %. In a similar way, it can be shown that the relative heat transfer measurements of R450A and R134a can be corroborated with an approximate analysis if the R450A liquid thermal conductivity and liquid viscosity are reduced and increased, respectively, by approximately 5 % along with an average 4 % mixture degradation effect.

The following measurement correlation was developed to have use of a more accurate representation of the data than eq. (4) or the Diani et al. (2014) model for comparing the flow boiling heat transfer performance of the fluids at the same heat transfer conditions:

$$\mathrm{Nu_p} = 6293\,\mathrm{Re}^{0.15}\,\mathrm{Pr}^{-1.43-3.54x_q}\left(\frac{P_s}{P_c}\right)^{-1.94x_q}\mathrm{Bo}^{0.32} \tag{6}$$

Figure 11 shows that eq. (6) predicts approximately 91 % of the measured convective boiling Nusselt numbers for R1234yf, R134a, and R450A in the micro-fin tube to within approximately ± 20 %. The gray dashed lines of Fig. 11 are multi-use 95 % confidence intervals on the mean prediction, which vary from ± 7 % of the prediction at a Nu of approximately 140 to approximately ± 3 % for Nusselt numbers around 300. Equation (6) is not recommended for general use because the Prandtl number exponent is negative, which may be a consequence of the correlation compensating for inaccurate liquid thermal conductivity and liquid viscosity properties for the two low GWP refrigerants. This notwithstanding, eq. (6) acceptably reproduces the convective boiling heat transfer measurements of this study so that a fair comparison can be made between fluids.

Representative plots of the heat transfer coefficient ($h_{2\phi}$) versus thermodynamic quality (x_q) for each of the three test fluids are given in Figs. 12 and 13 for counterflow and parallel flow configurations, respectively. The solid lines are predictions for the present micro-fin tube geometry, which were obtained from eqs. (5) and (6). The symbols are the measured data points, while the shaded regions between the dashed lines provide the measurement uncertainty for a 95 % confidence level. For counterflow (Fig. 11), the uncertainty in the R1234yf and R134a heat transfer coefficients is shown to be roughly 900 $\mathrm{W \cdot K^{-1} \cdot m^{-2}}$ (± 24 %) for most of data for qualities greater than 10 %. For these measurements, the uncertainty in the heat flux is the greatest contributor to the uncertainty in the heat transfer coefficient. The uncertainty in the R450A heat transfer coefficient is approximately 17 % less than that of R1234yf and R134a for this particular example and is shown to be roughly 750 $\mathrm{W \cdot K^{-1} \cdot m^{-2}}$ (± 20 %) for most of data for qualities greater than 35 %. This result is primarily due to the R450A heat flux measurements generally having an approximately 17 % smaller uncertainty than that for R1234yf and R134a measurements. For parallel flow with qualities less than 40 %, the uncertainty in the heat transfer coefficients is essentially the same as quoted above for counterflow, i.e., ± 24 % for R1234yf and R134a and ± 20 % for R450A. For qualities greater than 40 %, the uncertainty in the heat transfer coefficient is roughly 1600 $\mathrm{W \cdot K^{-1} \cdot m^{-2}}$ (± 40 %). The large uncertainty in the heat transfer coefficient for parallel flow and the high-quality region is due to the large uncertainty in the measurement of a small heat flux and a small wall superheat.

Figure 12 shows the local heat transfer coefficient for R1234yf, R134a, and R450A for G_r ~ 200 kg $\mathrm{s^{-1} m^{-2}}$ and P_s/P_c ~ 0.1 with counterflow between the refrigerant and the water. The P_s/P_c ratio is evaluated at the exit of the test section. As shown in Fig. 7, the counterflow condition provided increasing heat flux with increasing thermodynamic quality. As the convective boiling heat transfer coefficient is moderately dependent upon the heat flux, the increasing heat flux and the thinning liquid films on the wall cause the heat transfer coefficient to increase with respect to quality. Equation (5), together with eq. (6), is shown to predict both the R450A and the R134a measurements to within approximately 100 $\mathrm{W \cdot K^{-1} \cdot m^{-2}}$ (3 % to 6 %), for 75 % and 50 % of the measurements, respectively. Seventy-five percent of the R1234yf measurements are predicted to within approximately 200 $\mathrm{W \cdot K^{-1} \cdot m^{-2}}$, or approximately ± 7 %. Overall, the average difference between the measurements and the predictions for the counterflow measurements for R1234yf, R134a, and R450A was approximately ± 9 %, ± 5 %, and ± 2 %, respectively. Average agreement within

2 % indicates that the model is centered well about the data sets.

Figure 13 shows the local heat transfer coefficient for R1234yf, R134a, and R450A for G_r ~ 300 kg s^{-1}m^{-2} and P_s/P_c ~ 0.1 with parallel flow between the refrigerant and the water. As shown in Fig. 7, the parallel flow condition provided decreasing heat flux with increasing thermodynamic quality. Because of the high heat flux for qualities less than 20 %, it is likely that nucleate boiling provides a larger contribution to the total heat transfer than it is for the counterflow condition, thus contributing to the large heat transfer coefficient for the low-quality region. For qualities larger than 20 %, the effects of decreasing heat flux and the thinning liquid films on the wall cause the heat transfer coefficient to moderately decrease with respect to quality. Equation (5) with eq. (6) is shown to predict the heat transfer coefficient for the example parallel flow case to within 1100 W·K^{-1}·m^{-2} for the R1234yf and the R134a measurements. The best predictions are achieved for the lower qualities exhibiting the smallest deviations from the measurements of 100 W·K^{-1}·m^{-2} and 10 W·K^{-1}·m^{-2} for R1234yf and R134a, respectively. This is also true for the best R450A predictions, which are within approximately 50 W·K^{-1}·m^{-2} (2 %) of the measurements for a quality of roughly 40 %. The maximum deviation between the eq. (5) predictions and the measurements for R450A is approximately 800 W·K^{-1}·m^{-2}, or approximately ± 27 %. Overall, the average difference between the measurements and the predictions for the parallel flow measurements for R1234yf, R134a, and R450A was approximately ± 4 %, ± 1 %, and ± 1 %, respectively.

The main purpose of Figs. 12 and 13 was to compare the eq. (5) predictions to the measurements for each fluid at as similar as conditions as the present data set would allow. Even though the measurements were compared at nearly the same mass velocity, 200 kg s^{-1}m^{-2} for Fig. 12 and 300 kg s^{-1}m^{-2} for Fig. 13, the local heat flux could vary significantly between fluids. For the Fig. 12 example, the heat flux for R450A varied from approximately 0.3 kW·m^{-2} to approximately 18 kW·m^{-2}, while that for R1234yf varied from approximately 0.3 kW·m^{-2} to 11 kW·m^{-2}. This illustrates that the maximum heat flux for the R450A counterflow data set example was approximately 64 % larger than that for R1234yf, which accentuated the difference in the measured heat transfer coefficients between the two fluids. For this reason, it is important to use a validated model to compare the performance of the fluids at identical conditions in order to establish a fair comparison of heat transfer performance.

Figure 14 uses eq. (5) to illustrate the relative heat transfer performance of R1234yf, R134a, and R450A versus quality for the same saturated refrigerant inlet temperature ($T_{r,i}$ = 277.6 K), and the same refrigerant mass flux (G_r = 300 kg·m^{-2}·s^{-1}) for the present micro-fin tube geometry. Both counterflow and parallel flow conditions are shown. The counterflow heat flux is approximated with $q'' = 19.8 x_q^{0.67}$ kW·m^{-2}, while the parallel flow is approximated with $q'' = \left(13.1 - 10.7 x_q\right)$ kW·m^{-2}. The heat flux profiles with respect to quality that were used to calculate the heat transfer coefficient are approximately equivalent to those shown in Fig. 7 and adjusted to ensure that they provide the same total heat over the plotted quality range. Three different line styles for each flow condition are used to represent the predictions for the three different test fluids as labeled.

In general, for counterflow, Fig. 14 predictions show that the boiling heat-transfer coefficient rapidly increases with increasing quality for qualities less than 20 %. For quality ranges between 20 % and 70 %, the rate of increase in the heat transfer coefficient with respect to increasing quality is roughly a fourth of that for qualities less than 10 %. For parallel flow, the heat transfer coefficient for all the fluids decreases with increasing quality in response to the decreasing heat flux with respect to increasing quality. For the example case presented here, the heat transfer coefficient for R1234yf is, on average, approximately 5 % less than the heat transfer coefficient for R134a for qualities between 10 % and 70 % for both counterflow and parallel flow conditions. For both counterflow and parallel flow, the R1234yf heat transfer coefficient is nearly the same as that for R134a for qualities less than 20 %. As the quality increases beyond 20 %, the R1234yf heat transfer coefficient becomes increasingly smaller than that for R134a being approximately 10 % less than that for R134a at a quality of 70 %. As previously discussed, fluid properties shown in Table 2 would indicate that the difference between heat transfer coefficient for R1234yf and R134a should be larger than that which was measured. For the example case presented here, the heat transfer coefficient for R450A is, on average, approximately 15 % less than the heat transfer coefficient for R134a for the entire illustrated quality range for both counterflow and parallel flow conditions. The smaller heat transfer coefficient of R450A as compared to that of R134a is primarily due to the mixture degradation effect, as calculated by the bracketed right-side of eq. (5), being on average 0.96 as compared to 1 for R134a, and the liquid thermal conductivity of R450A being approximately 7 % less than that for R134a. The mixture degradation factor reduces the single component prediction by an amount that is required to account for the mixture degradation effects.

Fanning friction factor measurements that correspond to the heat transfer measurements are provided in Appendix C for R1234yf, R134a, and R450A. Appendix C also compares the measured Fanning friction factor to the Choi et al. (2001) correlation and, also to a new correlation that was developed in this study to better predict the measurements.

CONCLUSIONS

Local convective boiling heat transfer measurements for R134a and two low-GWP refrigerants (R1234yf and R450A) in a fluid heated micro-fin tube were presented. The new correlation for convective boiling Nusselt numbers for all the test refrigerants was developed that predicted approximately 90 % of the measurements to within ± 20 %. Measured Fanning friction factors were also presented and compared to a new predictive correlation that was a function of the all-liquid Reynolds number, the local thermodynamic quality, and the Boiling number. The developed Fanning friction factor correlation predicted approximately 76 % of the measured two-phase friction factors for R1234yf, R134a, and R450A in the micro-fin tube to within approximately ± 20 %.

In general, the measured boiling heat-transfer coefficient increased with increasing qualities when the local heat flux increased with respect to quality. In contrast, for decreasing heat flux with respect to increasing quality, the measured heat transfer coefficient was relatively constant. The heat transfer coefficient of the three test fluids were compared at the same heat flux, saturated refrigerant temperature, and refrigerant mass flux by using the developed correlation. The resulting example comparison showed that the heat transfer performance of R450A and R1234yf were, on average, 15 % less and 5 % less than that of the R134a, respectively. The greater heat transfer performance of R134a was due in part to its larger convective property group, and latent heat of vaporization as compared to R1234yf and R450A. In addition, R450A experienced an additional loss in flow boiling heat transfer, as compared to that of R134a, due to its small 0.64 K temperature glide.

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NOMENCLATURE

English symbols

A_c cross-sectional area (m^2)

Bo local boiling number, $\frac{q''}{G_r i_{fg}}$

c_p specific heat (J kg^{-1} K^{-1})

C coefficients given in eq. (5)

D_e equivalent inner diameter of smooth tube, $\sqrt{\frac{4A_c}{\pi}}$ (m)

D_h hydraulic diameter of micro-fin tube (m)

e fin height (mm)

f Fanning friction factor

g acceleration due to gravity (m/s^2)

G total mass velocity (kg m^{-2} s^{-1})

$h_{2\phi}$ local two-phase heat-transfer coefficient (W $m^{-2}\cdot K^{-1}$)

i_{fg} latent heat of vaporization (J kg^{-1})

k refrigerant thermal conductivity (W m^{-1} K^{-1})

K_f dimensionless two-phase number defined by eq. (C3)

Nu local Nusselt number based on D_h

$\dot{m}$ mass flow rate (kg s^{-1})

M_w molar mass (g $mole^{-1}$)

p wetted perimeter (m)

P local fluid pressure (Pa)

Pr liquid refrigerant Prandtl number $\left.\frac{c_p \mu}{k}\right|_{r,l}$

q'' local heat flux based on A_i (W m^{-2})

Re all liquid, refrigerant Reynolds number based on $D_h = \frac{G_r D_h}{\mu_{r,l}}$

S_v non-dimensional refrigerant specific volume given in Appendix A: $\frac{v_v - v_l}{v}$

s distance between fins (mm)

T temperature (K)

t_b bottom thickness of fin (mm)

t_w tube wall thickness (mm)

U expanded relative uncertainty (%)

x_q thermodynamic mass quality (-)

z axial distance (m)

Greek symbols

α helix angle (°)

β fin angle (°)

ΔL incremental length (m)

ΔT_s T_s - T_w (K)

μ viscosity (Pa·s)
ν specific volume, $x_q \nu_v + (1-x_q) \nu_l$ (m^3 kg^{-1})
ρ density (kg m^{-3})
σ surface tension (kg s^{-2})

Subscripts
b bubble point
c critical condition
d dew point
f water
i inside, inlet
l liquid
o outlet, exit
p prediction, single component
r refrigerant
s saturated state
v vapor
w heat transfer surface

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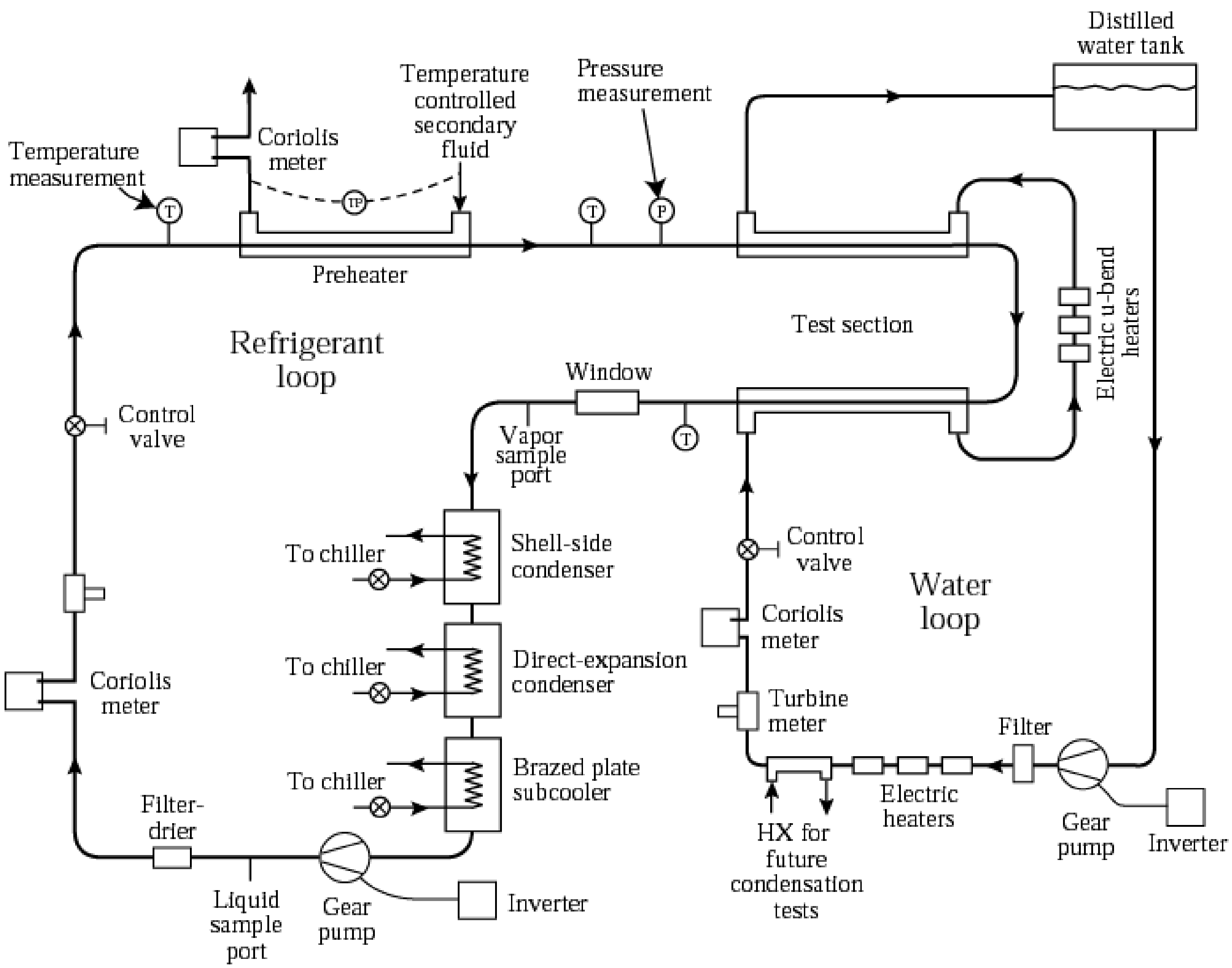

Figure 1 Schematic of test rig showing counterflow arrangement

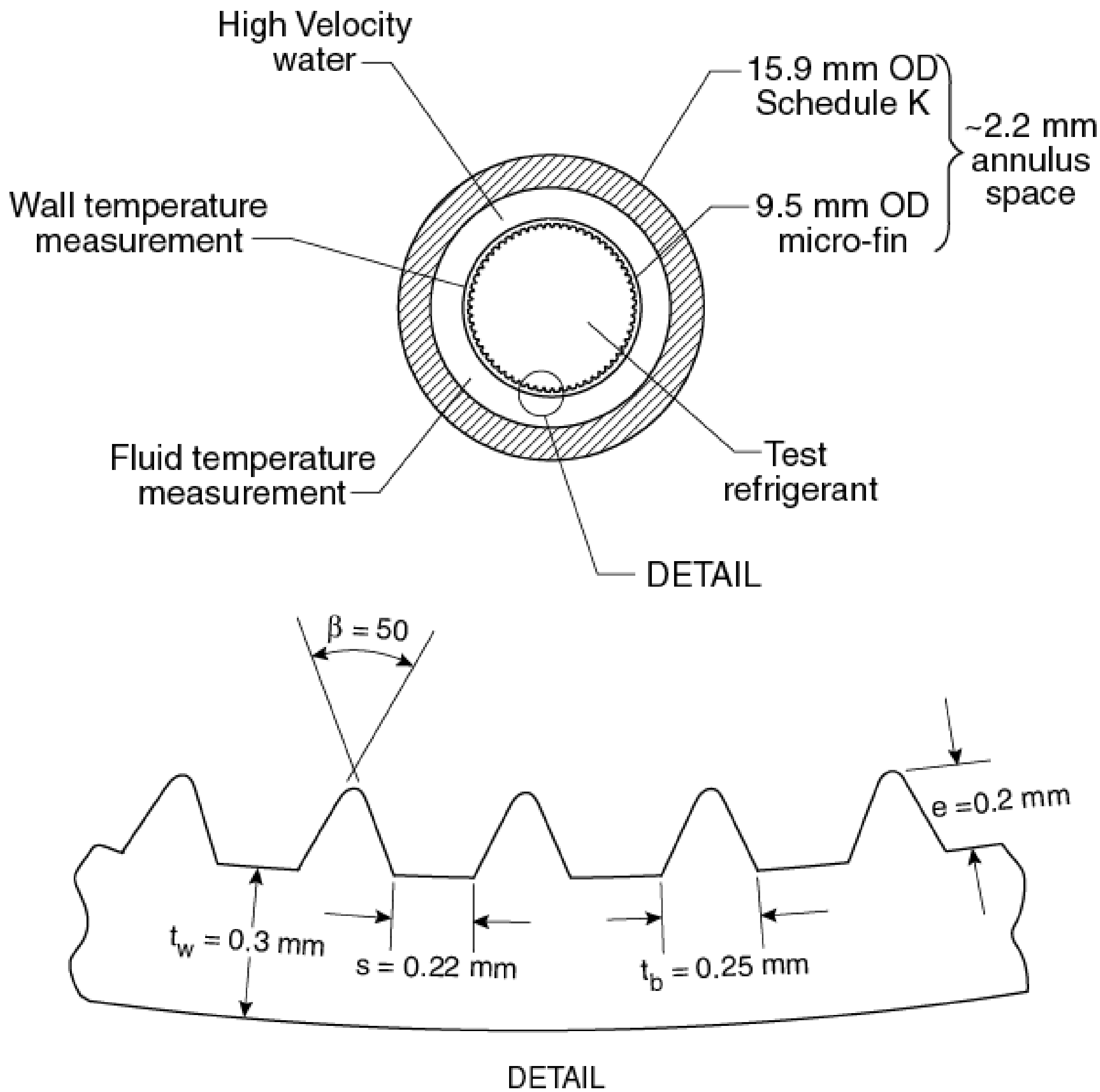

Figure 2 Test section cross section

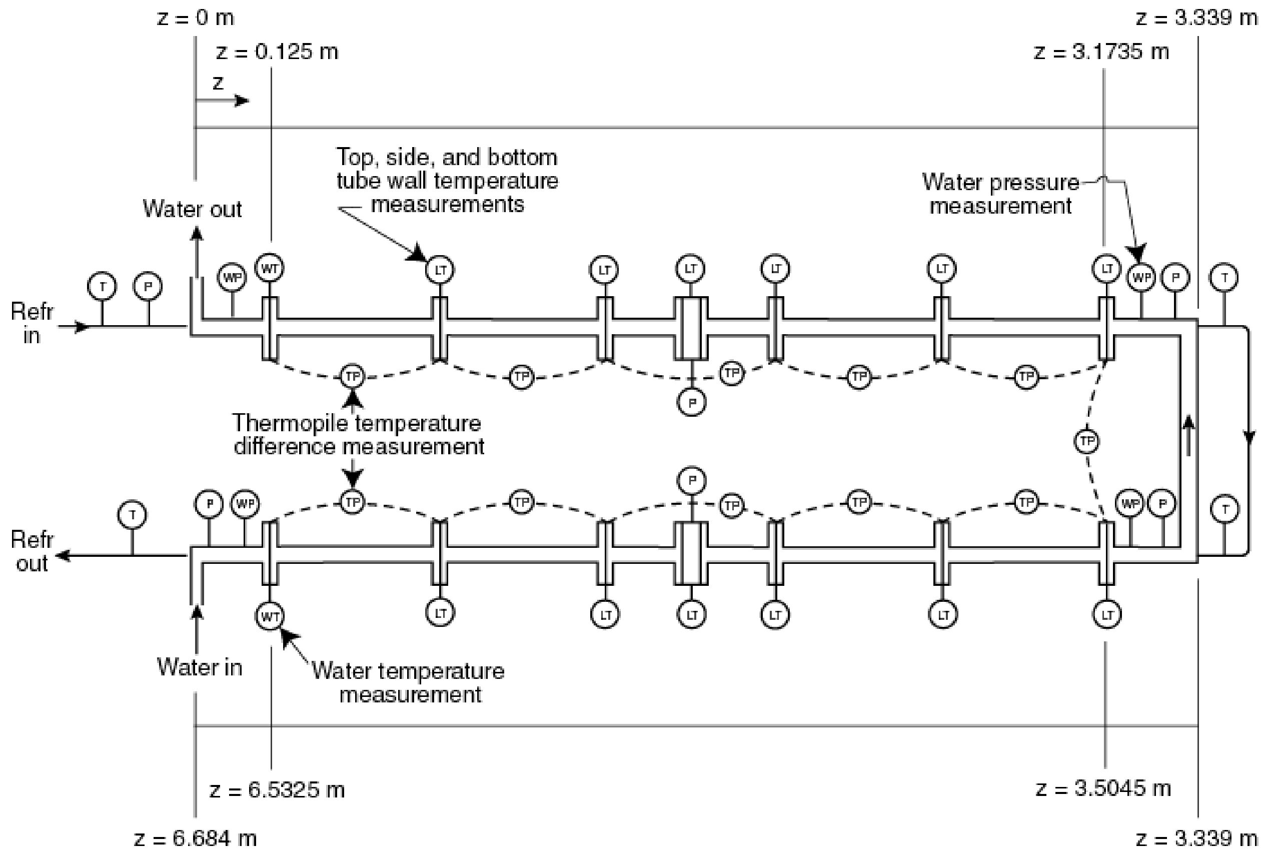

Figure 3 Detailed schematic of test section (counterflow)

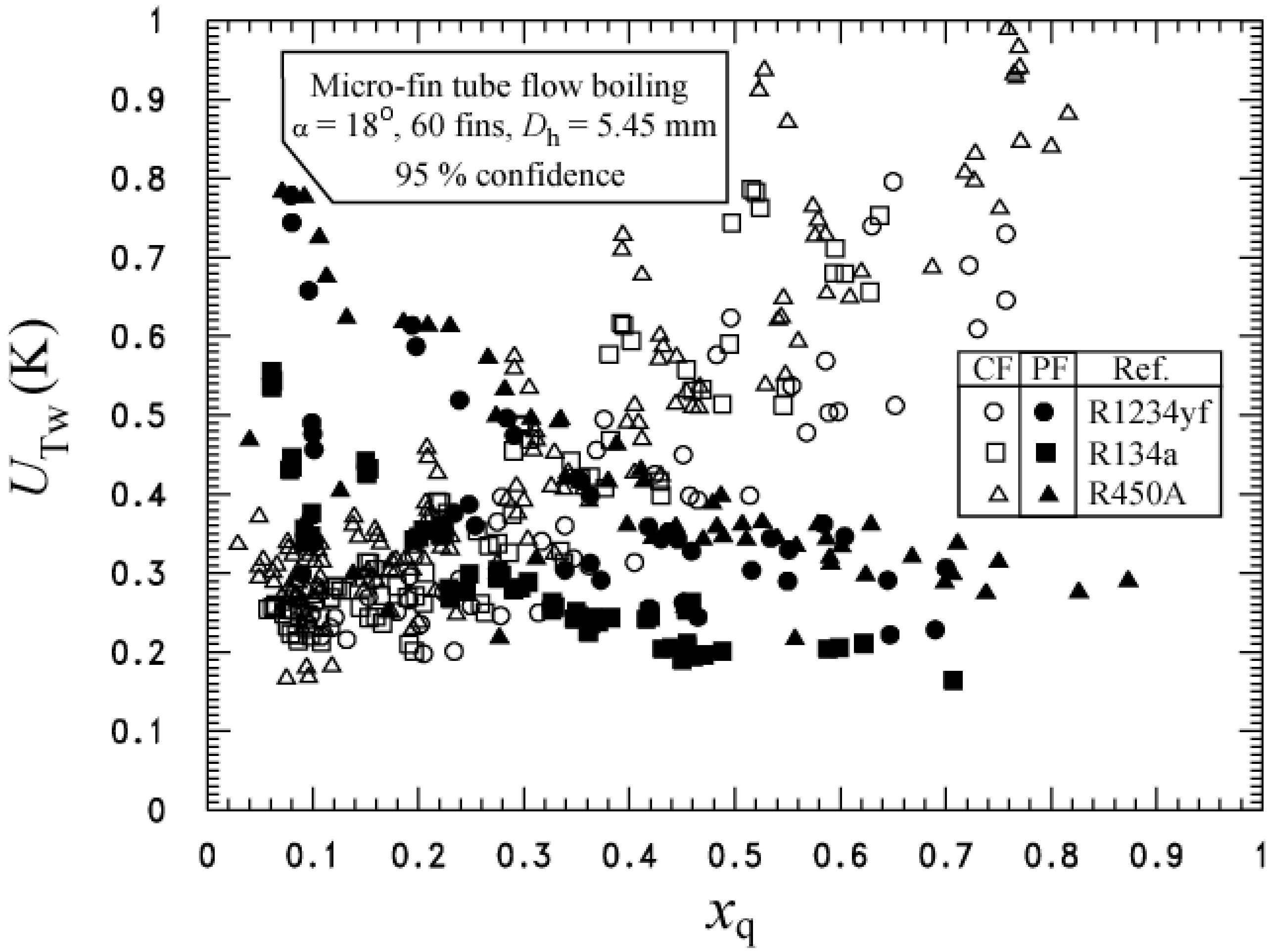

Figure 4 Uncertainty of inner wall temperature

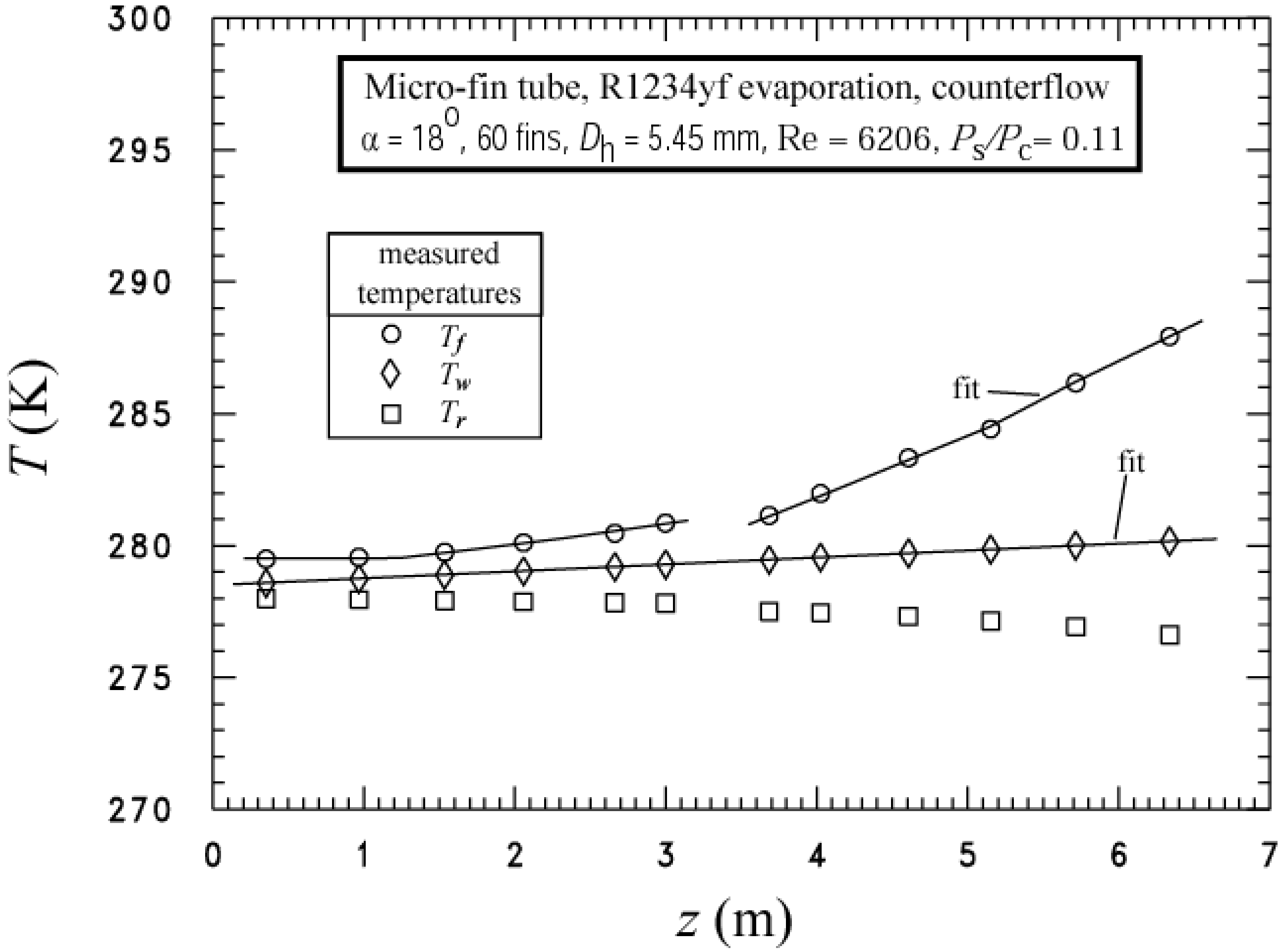

Figure 5 Counterflow temperature profiles for a R1234yf test

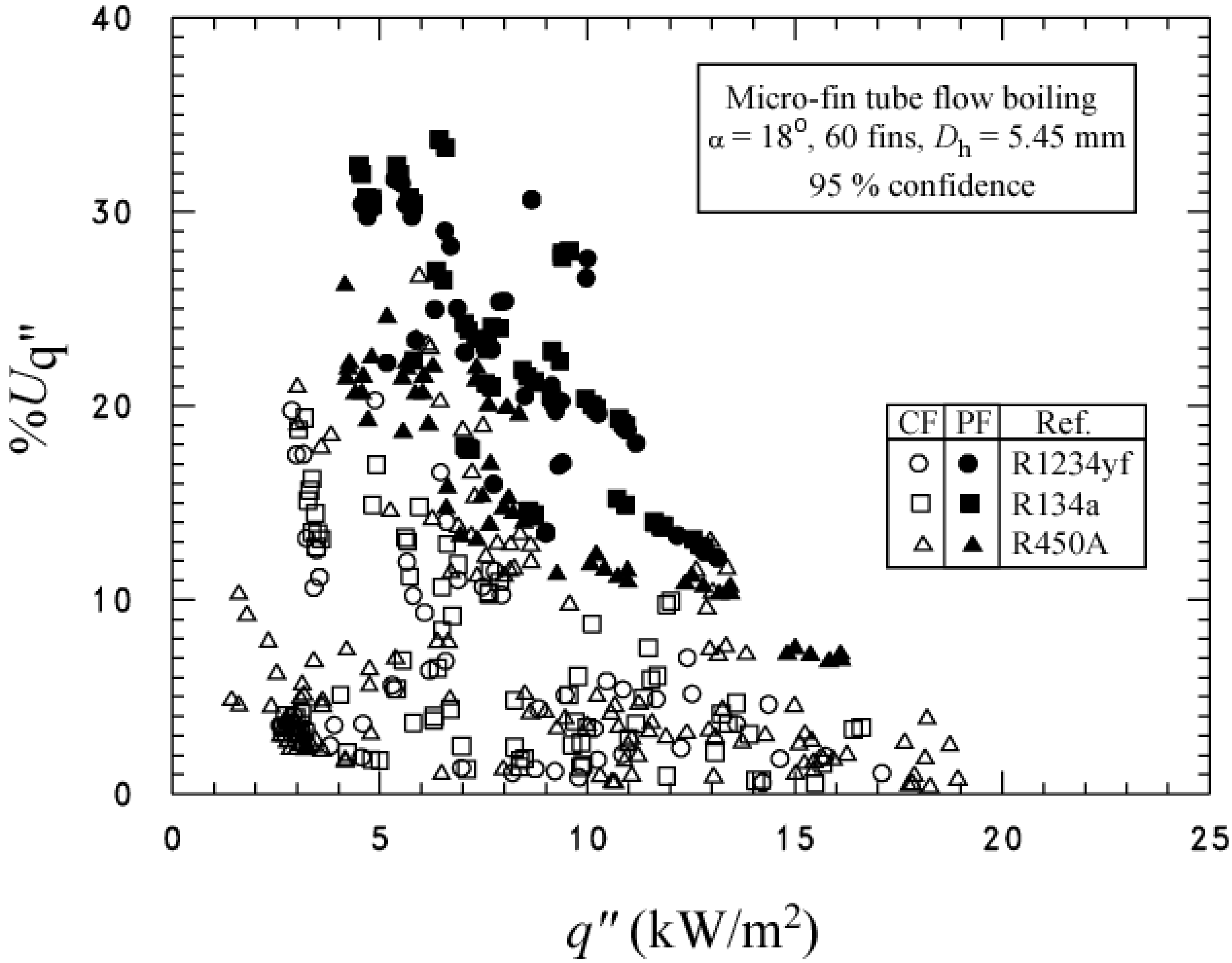

Figure 6 Relative uncertainty of the heat flux

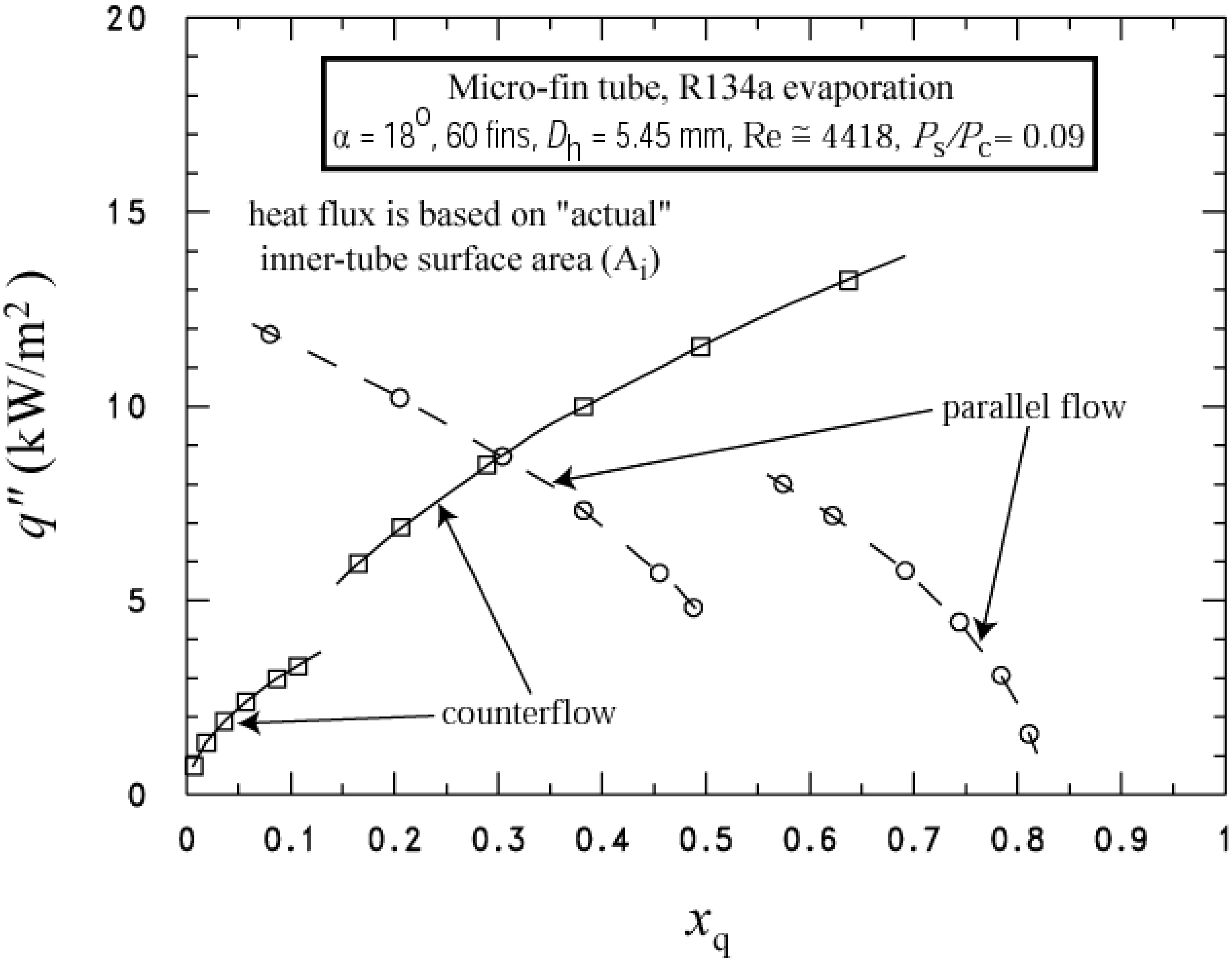

Figure 7 Heat flux distribution for R134a

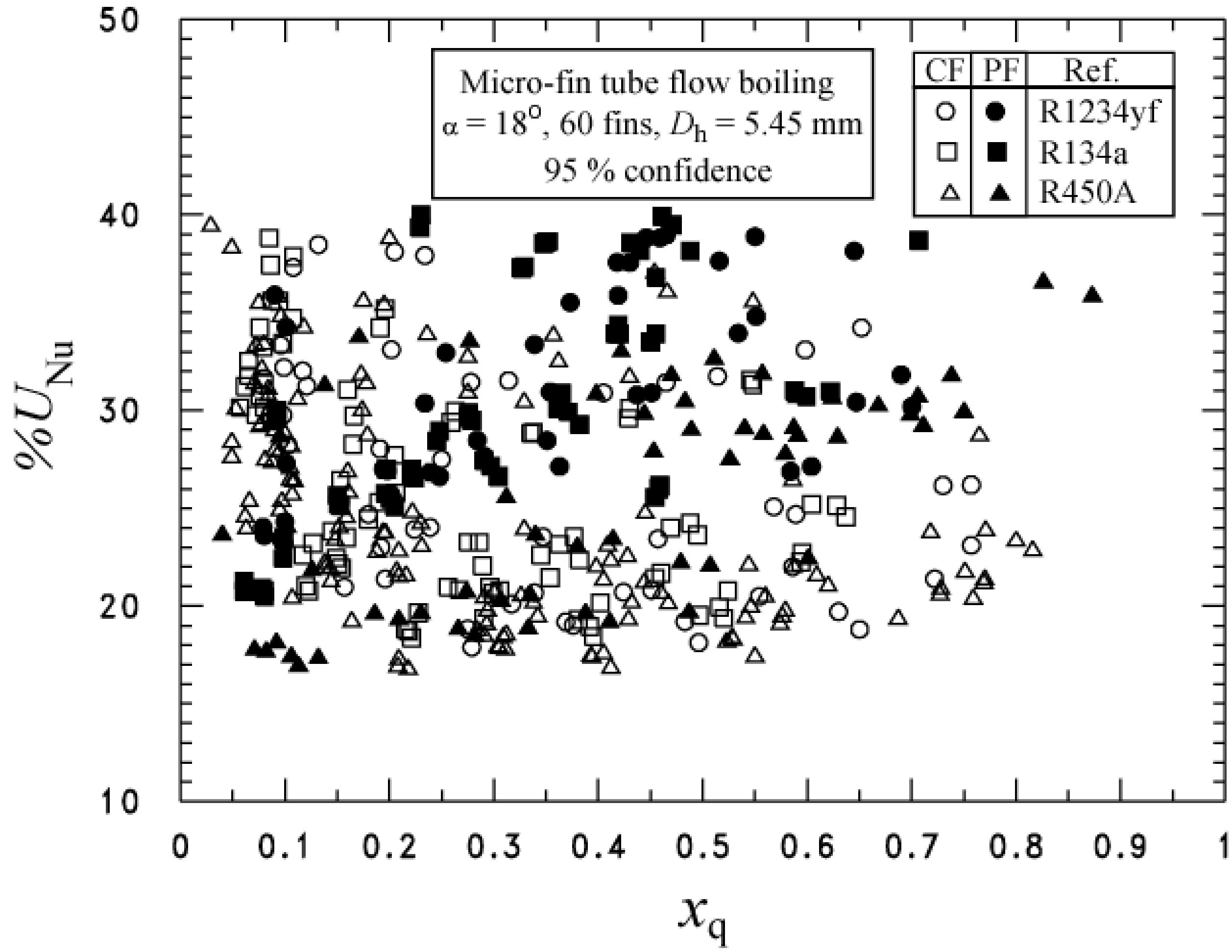

Figure 8 Relative uncertainty of the Nusselt number with respect to the quality

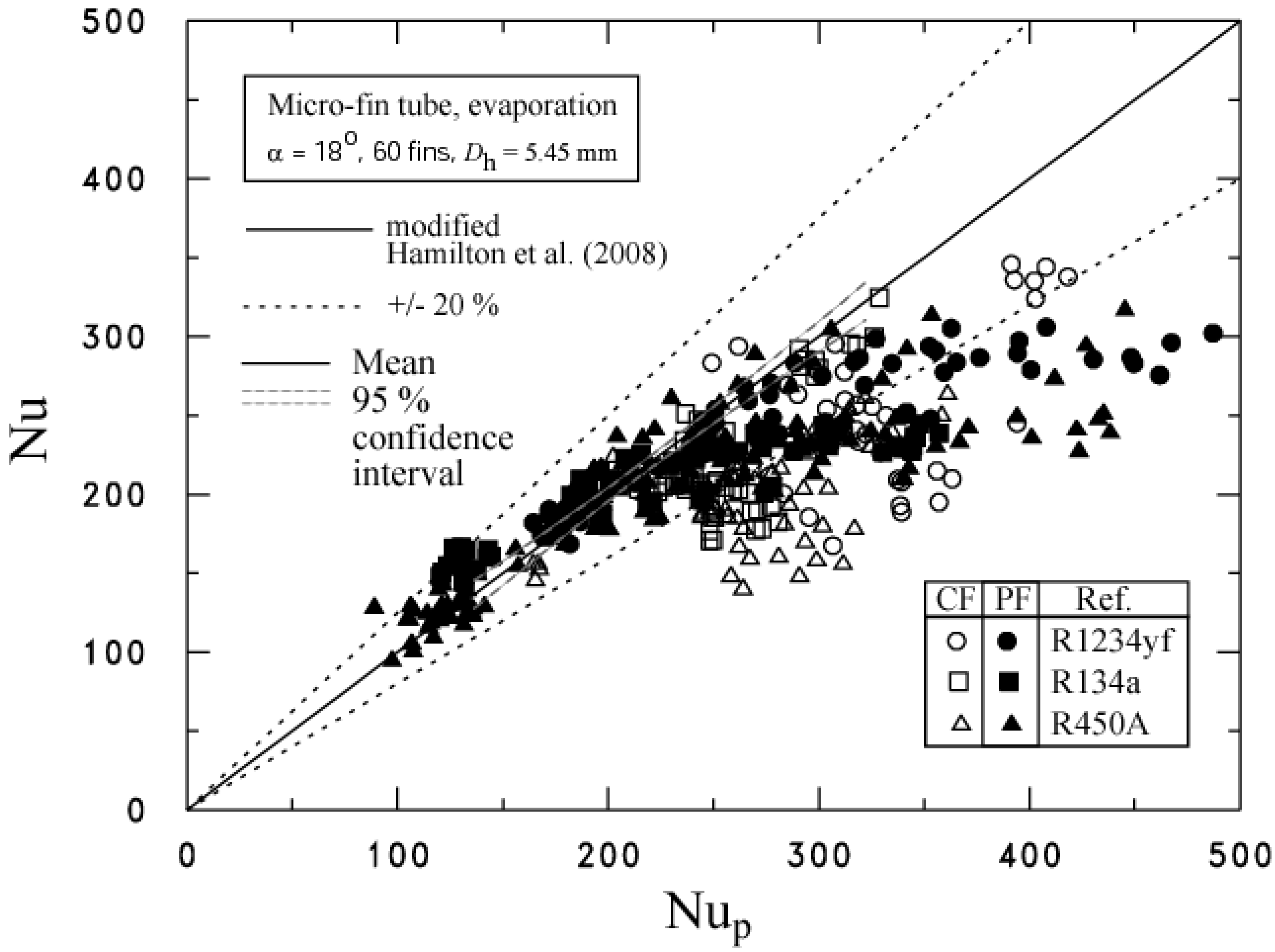

Figure 9 Comparison between measured Nusselt numbers and those predicted by the modified Hamilton et al. (2008) correlation

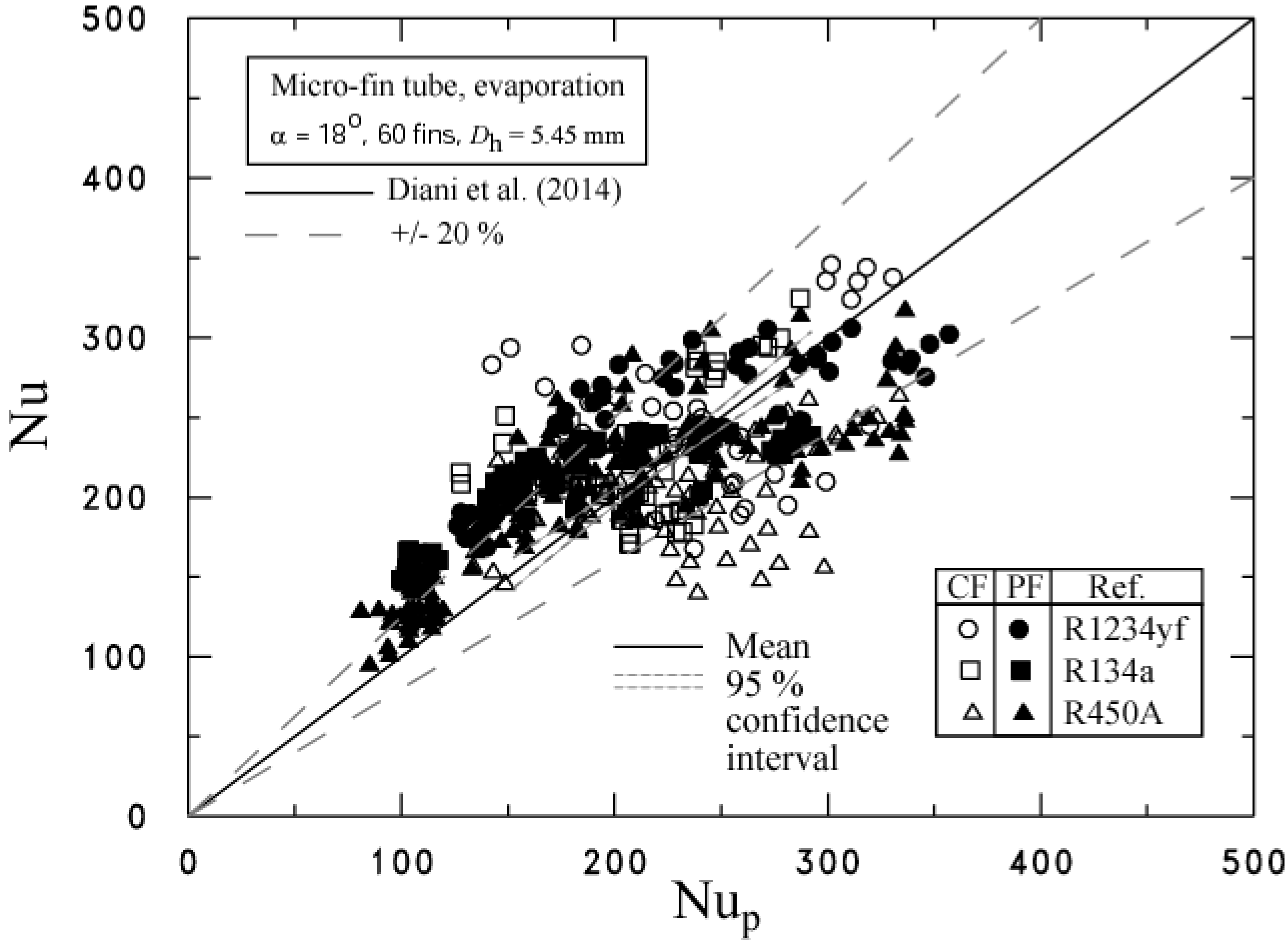

Figure 10 Comparison between measured Nusselt numbers and those predicted by the Diani et al. (2014) correlation

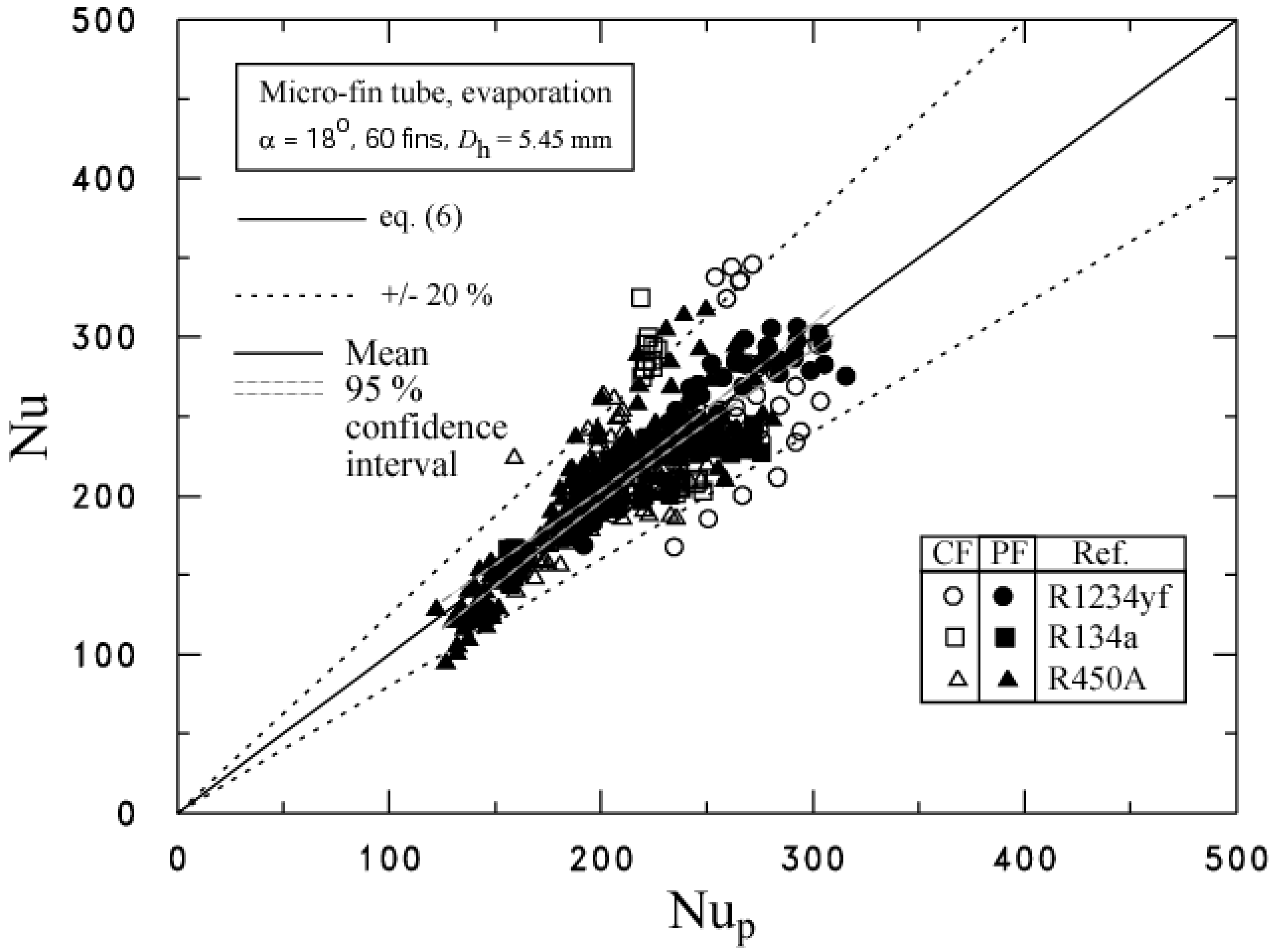

Figure 11 Comparison between measured Nusselt numbers and those predicted by eq. (6)

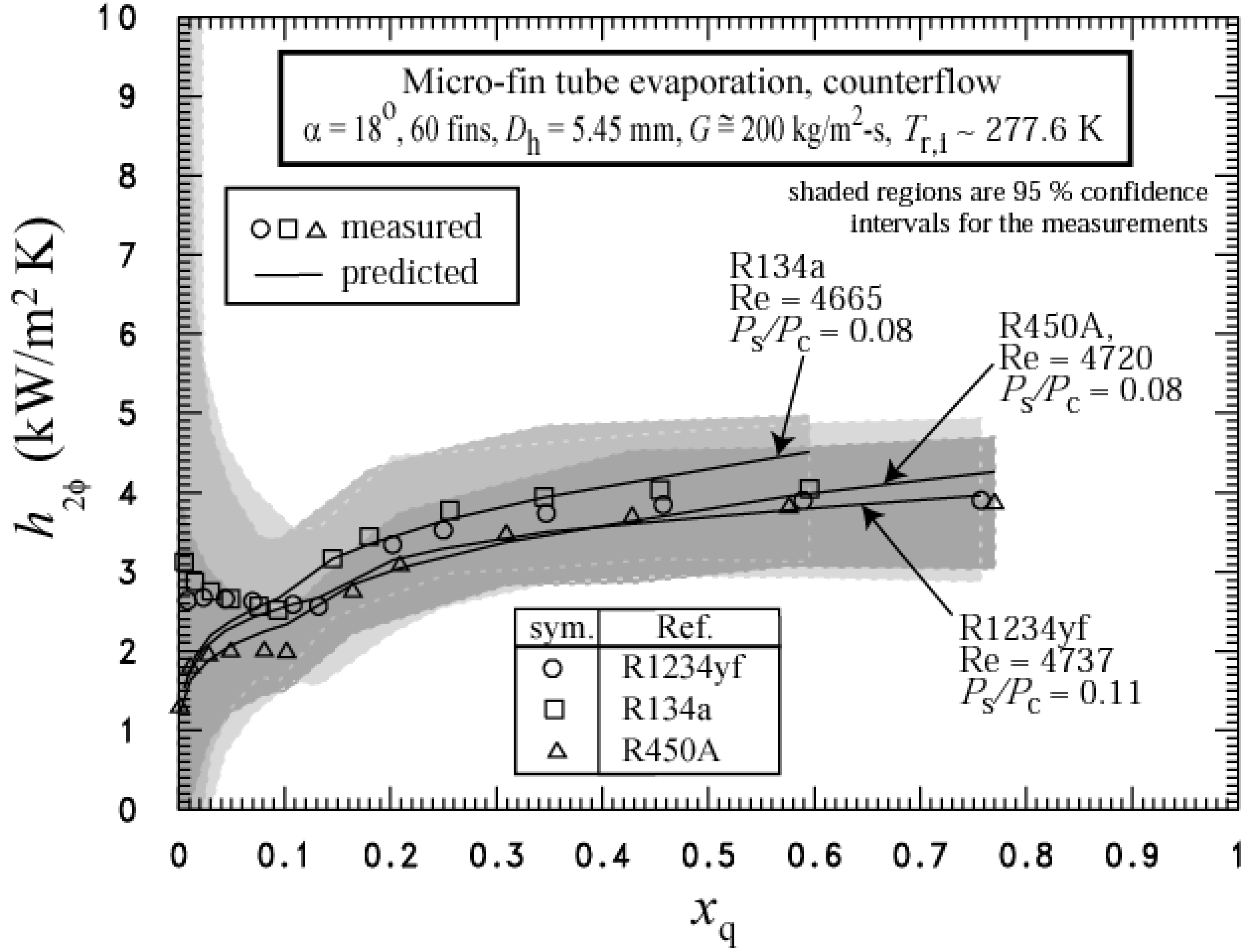

Figure 12 Flow boiling heat transfer coefficient for micro-fin tube versus thermodynamic quality for R450A, R134a, and R1234yf (counterflow)

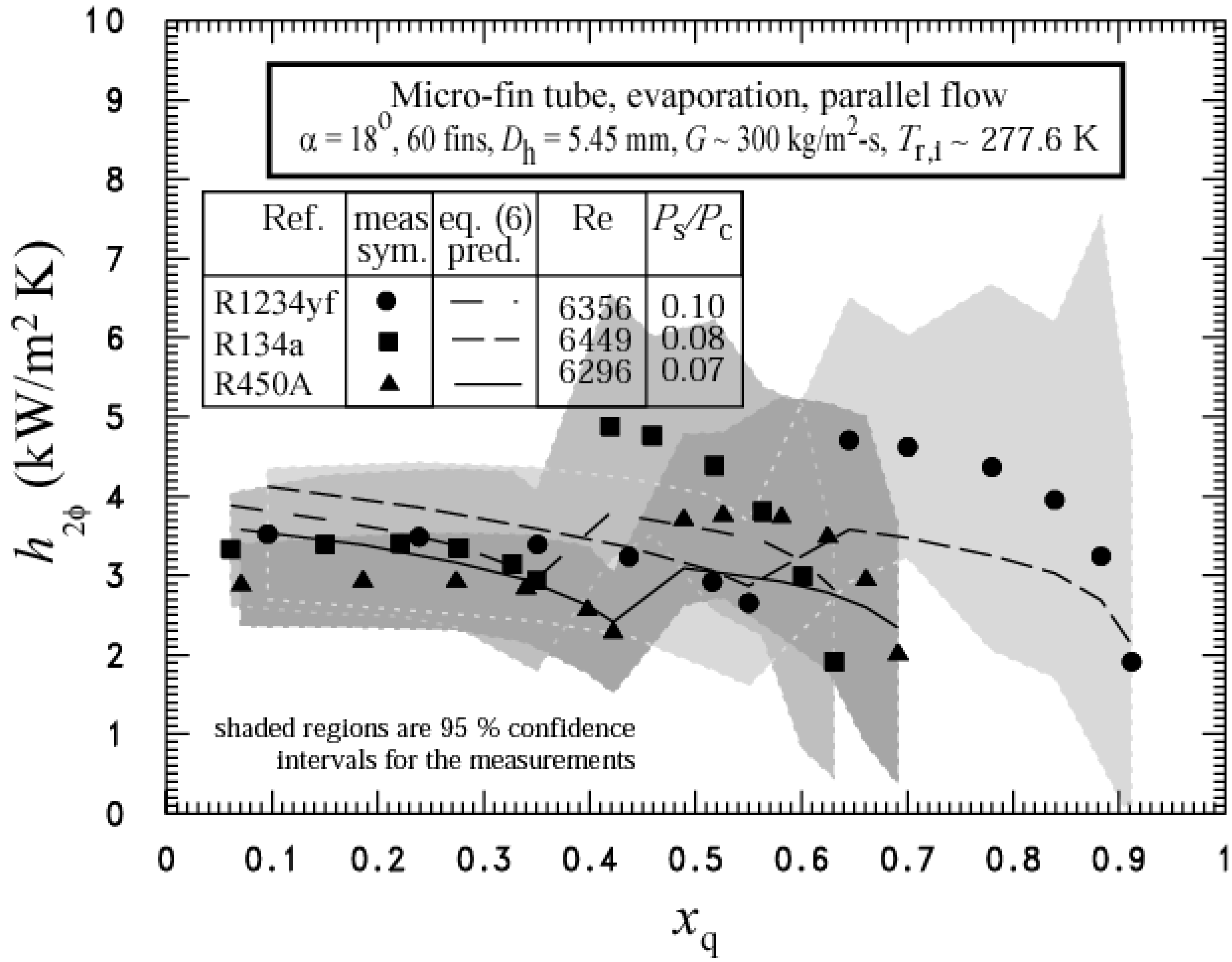

Figure 13 Flow boiling heat transfer coefficient for micro-fin tube versus thermodynamic quality for R450A, R134a, and R1234yf (parallel flow)

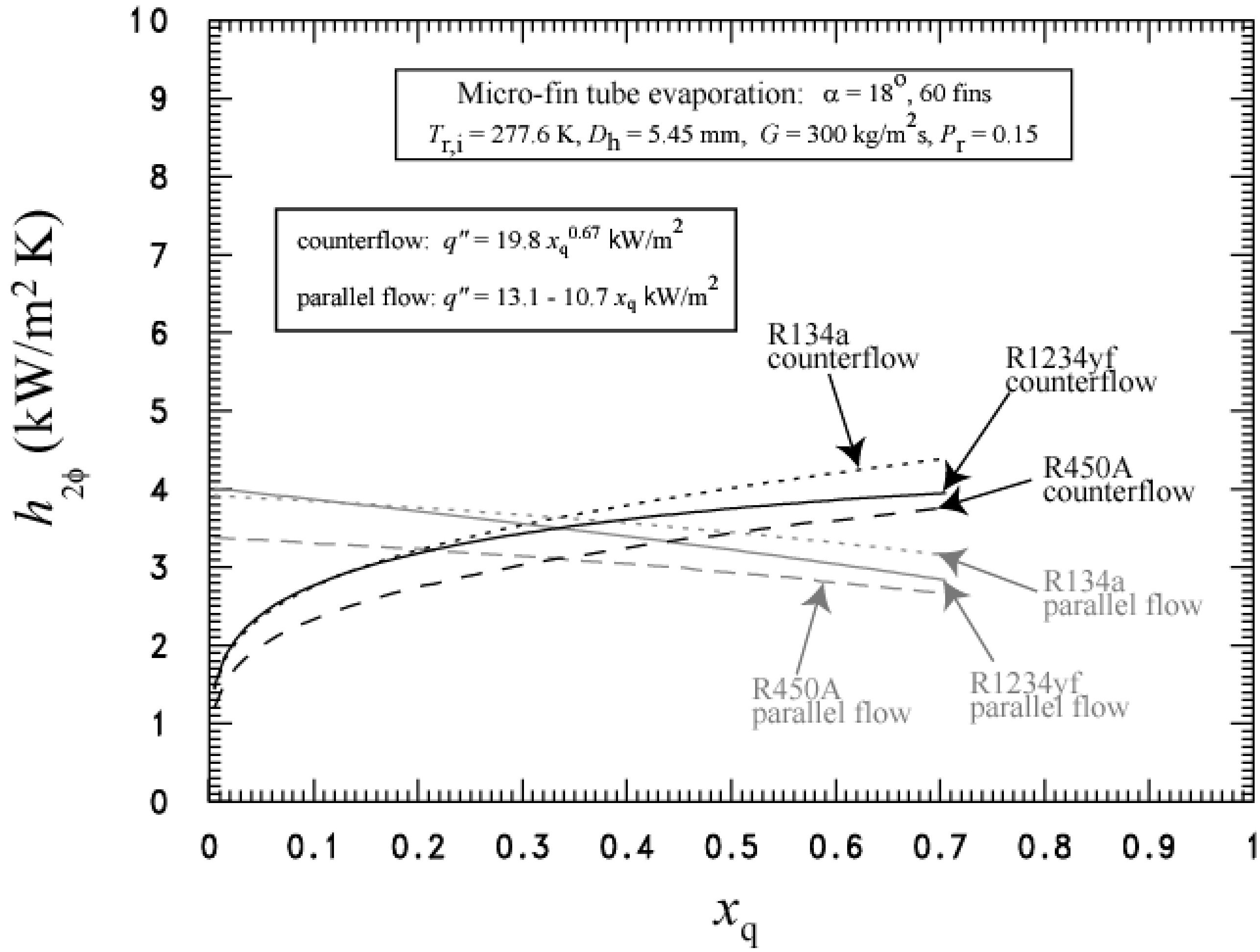

Figure 14 Flow boiling heat transfer coefficient versus thermodynamic quality for test refrigerants

Table 1 Median estimated 95 % relative expanded uncertainties for measurements (U)

Parameter	Minimum	Maximum	U %
G_r [kg m^{-2}·s^{-1}]	96	318	2.0
T_s [K]	273.8	281.8	0.1 (0.3 K)
P [kPa]	273	369	1.5
T_w [K]	276.1	285.0	0.1 (0.4 K)
$\dot{m}_f$ [kg s^{-1}]	0.006	0.019	2.0
T_f [K]	278.3	295.4	0.1
P_f [kPa]	200	110	1.0
q'' [kW m^{-2}]	1.4	18.9	15
$(T_d - T_b)/T_b$	0	0.002	3.0
Nu	94	346	20
Re	2102	8242	4.0
Bo	0.000039	0.00049	16.0
Pr	3.5	4.0	2.0
P_s/P_c	0.07	0.11	2.0
x_q	0.03	0.87	8.0
ΔT_s [K]	0.96	5.41	0.44 K

Table 2 Representative properties from REFPROP (Lemmon et al. 2013)

Test fluid	Evaluated at average test conditions for each fluid				Evaluated at T_s = 277.6 K					
	$T_d - T_b$ (K)	k_l (W m^{-1} K^{-1})	Pr	σ (mN m^{-1})	ρ_l (kg m^{-3})	ρ_v (kg m^{-3})	$[P_s]_{xq=0}$ (kPa)	c_p (J kg^{-1}K^{-1})	i_{fg} (KJ kg^{-1})	μ_l (μPa s)
R1234yf	0	0.070	3.5	8.85	1162.2	20.4	366.3	1306	160.39	197.31
R134a	0	0.090	3.8	10.8	1279.9	16.8	343.0	1354	195.17	251.86
R450A	0.64	0.084	4.0	11.4	1244.5	15.4	304.0	1339	185.62	249.45

APPENDIX A1

Convective boiling of R1234yf within a micro-fin tube
(file: TaevapGWP3.dat)

Nu	Re	x_q	Bo	P_s/P_c	T_s/T_c	M_w	Sv	Pr	flow	U_{Nu}
125.2	6240.	0.007	0.20060×10^{-4}	0.110	0.756	114.04	40.12	3.47	C	711.34
164.5	6237.	0.020	0.37850×10^{-4}	0.110	0.756	114.04	26.13	3.48	C	86.32
180.5	6234.	0.040	0.54290×10^{-4}	0.109	0.755	114.04	17.32	3.48	C	60.27
187.1	6232.	0.064	0.69410×10^{-4}	0.109	0.755	114.04	12.24	3.48	C	44.88
189.7	6229.	0.099	0.86890×10^{-4}	0.109	0.755	114.04	8.57	3.48	C	32.18
189.7	6227.	0.121	0.96550×10^{-4}	0.109	0.755	114.04	7.18	3.48	C	31.23
267.9	6204.	0.191	0.17915×10^{-3}	0.108	0.754	114.04	4.79	3.49	C	28.01
283.0	6200.	0.239	0.20719×10^{-3}	0.108	0.754	114.04	3.89	3.49	C	24.02
298.6	6190.	0.339	0.25535×10^{-3}	0.107	0.754	114.04	2.80	3.49	C	20.68
305.2	6177.	0.451	0.30011×10^{-3}	0.107	0.753	114.04	2.13	3.49	C	20.80
305.9	6160.	0.586	0.34633×10^{-3}	0.106	0.753	114.04	1.66	3.49	C	22.00
302.1	6136.	0.757	0.39695×10^{-3}	0.105	0.752	114.04	1.29	3.50	C	23.10
144.3	7947.	0.007	0.17200×10^{-4}	0.108	0.755	114.04	39.51	3.48	C	208.90
175.0	7942.	0.019	0.30370×10^{-4}	0.108	0.755	114.04	27.47	3.48	C	90.42
184.2	7938.	0.034	0.42540×10^{-4}	0.108	0.754	114.04	19.25	3.49	C	60.74
185.2	7933.	0.053	0.53730×10^{-4}	0.108	0.754	114.04	14.13	3.49	C	44.64
182.1	7928.	0.080	0.66670×10^{-4}	0.108	0.754	114.04	10.22	3.49	C	31.64
179.2	7925.	0.098	0.73810×10^{-4}	0.107	0.754	114.04	8.67	3.48	C	29.74
253.6	7886.	0.153	0.14280×10^{-3}	0.106	0.753	114.04	5.87	3.49	C	25.33
270.1	7879.	0.192	0.16804×10^{-3}	0.106	0.753	114.04	4.77	3.50	C	23.00
286.1	7861.	0.275	0.21140×10^{-3}	0.105	0.752	114.04	3.42	3.50	C	18.82
290.8	7838.	0.369	0.25166×10^{-3}	0.104	0.752	114.04	2.59	3.50	C	19.18
289.2	7806.	0.483	0.29318×10^{-3}	0.103	0.751	114.04	2.00	3.51	C	19.20
282.7	7763.	0.630	0.33859×10^{-3}	0.102	0.749	114.04	1.55	3.52	C	19.70
283.6	4565.	0.568	0.32924×10^{-3}	0.106	0.753	114.04	1.71	3.49	C	25.07
285.3	4557.	0.730	0.37942×10^{-3}	0.105	0.752	114.04	1.34	3.50	C	26.15
569.5	3230.	0.007	0.18340×10^{-4}	0.108	0.755	114.04	40.15	3.48	C	1125.70
263.6	3229.	0.020	0.39330×10^{-4}	0.108	0.755	114.04	26.23	3.48	C	206.55
228.3	3228.	0.041	0.58730×10^{-4}	0.108	0.755	114.04	17.03	3.48	C	111.45
214.4	3227.	0.067	0.76580×10^{-4}	0.108	0.755	114.04	11.80	3.48	C	77.05
205.7	3227.	0.106	0.97220×10^{-4}	0.108	0.755	114.04	8.10	3.48	C	52.97
202.5	3226.	0.131	0.10864×10^{-3}	0.108	0.755	114.04	6.72	3.48	C	53.24
206.2	3222.	0.194	0.14566×10^{-3}	0.108	0.754	114.04	4.71	3.49	C	56.36
216.9	3221.	0.234	0.16855×10^{-3}	0.108	0.754	114.04	3.98	3.49	C	37.92
230.2	3220.	0.314	0.20781×10^{-3}	0.108	0.754	114.04	3.01	3.49	C	31.51
238.2	3218.	0.405	0.24439×10^{-3}	0.107	0.754	114.04	2.37	3.49	C	30.88
244.0	3216.	0.514	0.28226×10^{-3}	0.107	0.754	114.04	1.88	3.49	C	31.73
247.9	3214.	0.652	0.32387×10^{-3}	0.107	0.754	114.04	1.49	3.49	C	34.21
259.4	6477.	0.096	0.34148×10^{-3}	0.109	0.755	114.04	8.77	3.48	P	23.44
256.6	6468.	0.239	0.29046×10^{-3}	0.108	0.755	114.04	3.89	3.48	P	26.82
249.8	6458.	0.351	0.24319×10^{-3}	0.108	0.754	114.04	2.71	3.49	P	28.44

237.9	6446.	0.437	0.19964×10^{-3}	0.107	0.754	114.04	2.20	3.49	P	30.77
214.7	6429.	0.516	0.14926×10^{-3}	0.106	0.753	114.04	1.87	3.49	P	37.62
195.0	6419.	0.550	0.12133×10^{-3}	0.106	0.753	114.04	1.76	3.49	P	38.87
343.9	6317.	0.645	0.22926×10^{-3}	0.102	0.749	114.04	1.51	3.52	P	38.14
337.8	6303.	0.700	0.20431×10^{-3}	0.101	0.749	114.04	1.40	3.52	P	30.18
318.9	6279.	0.780	0.16251×10^{-3}	0.100	0.748	114.04	1.26	3.53	P	52.58
288.3	6255.	0.839	0.12349×10^{-3}	0.099	0.747	114.04	1.17	3.53	P	56.66
235.9	6229.	0.883	0.83110×10^{-4}	0.098	0.746	114.04	1.11	3.54	P	131.85
139.2	6200.	0.912	0.38720×10^{-4}	0.096	0.745	114.04	1.08	3.55	P	149.98
240.4	8242.	0.079	0.27427×10^{-3}	0.108	0.755	114.04	10.38	3.48	P	24.03
241.4	8228.	0.194	0.23335×10^{-3}	0.108	0.754	114.04	4.73	3.49	P	26.98
237.8	8211.	0.284	0.19543×10^{-3}	0.107	0.754	114.04	3.31	3.49	P	28.46
229.0	8191.	0.354	0.16051×10^{-3}	0.106	0.753	114.04	2.69	3.49	P	30.93
207.8	8163.	0.418	0.12012×10^{-3}	0.105	0.752	114.04	2.30	3.50	P	37.56
188.8	8146.	0.446	0.97730×10^{-4}	0.105	0.752	114.04	2.16	3.50	P	38.82
335.6	7965.	0.534	0.20665×10^{-3}	0.099	0.747	114.04	1.82	3.54	P	33.94
323.9	7940.	0.584	0.18574×10^{-3}	0.098	0.746	114.04	1.67	3.54	P	26.86
291.9	7893.	0.658	0.15112×10^{-3}	0.096	0.745	114.04	1.48	3.55	P	43.52
246.6	7845.	0.715	0.11881×10^{-3}	0.095	0.744	114.04	1.37	3.56	P	44.28
185.5	7790.	0.760	0.85380×10^{-4}	0.093	0.742	114.04	1.29	3.57	P	84.56
106.5	7724.	0.794	0.48700×10^{-4}	0.091	0.740	114.04	1.24	3.59	P	89.82
211.6	4895.	0.100	0.32128×10^{-3}	0.104	0.751	114.04	8.52	3.51	P	24.31
200.5	4890.	0.234	0.27216×10^{-3}	0.104	0.751	114.04	3.98	3.51	P	30.35
185.6	4885.	0.339	0.22666×10^{-3}	0.104	0.751	114.04	2.81	3.51	P	33.36
167.7	4878.	0.419	0.18473×10^{-3}	0.103	0.751	114.04	2.30	3.51	P	35.87
139.8	4869.	0.491	0.13622×10^{-3}	0.103	0.750	114.04	1.97	3.52	P	46.53
120.2	4863.	0.521	0.10933×10^{-3}	0.102	0.750	114.04	1.86	3.51	P	46.92
211.2	4818.	0.600	0.19214×10^{-3}	0.100	0.748	114.04	1.62	3.53	P	52.22
209.8	4812.	0.647	0.17745×10^{-3}	0.100	0.748	114.04	1.51	3.53	P	30.41
205.5	4802.	0.718	0.15273×10^{-3}	0.099	0.747	114.04	1.36	3.53	P	68.77
199.4	4792.	0.776	0.12965×10^{-3}	0.098	0.747	114.04	1.26	3.54	P	63.65
189.2	4782.	0.825	0.10573×10^{-3}	0.098	0.746	114.04	1.19	3.54	P	77.26
171.7	4771.	0.868	0.79420×10^{-4}	0.097	0.746	114.04	1.13	3.55	P	87.35
283.2	3432.	0.090	0.31673×10^{-3}	0.108	0.754	114.04	9.27	3.48	P	35.88
267.9	3431.	0.221	0.26510×10^{-3}	0.108	0.754	114.04	4.18	3.49	P	48.86
248.9	3429.	0.322	0.21730×10^{-3}	0.108	0.754	114.04	2.94	3.49	P	56.27
225.5	3427.	0.397	0.17327×10^{-3}	0.108	0.754	114.04	2.41	3.49	P	56.30
187.9	3425.	0.463	0.12231×10^{-3}	0.107	0.754	114.04	2.08	3.49	P	76.85
160.4	3424.	0.490	0.94080×10^{-4}	0.107	0.754	114.04	1.97	3.49	P	78.48
370.8	3411.	0.566	0.20245×10^{-3}	0.106	0.753	114.04	1.71	3.49	P	107.51
360.6	3409.	0.614	0.17657×10^{-3}	0.106	0.753	114.04	1.58	3.49	P	56.34
335.9	3405.	0.681	0.13239×10^{-3}	0.106	0.753	114.04	1.43	3.50	P	126.81
298.0	3402.	0.725	0.91160×10^{-4}	0.105	0.752	114.04	1.35	3.50	P	119.66
225.3	3399.	0.755	0.48410×10^{-4}	0.105	0.752	114.04	1.30	3.50	P	11621.95
11.6	3396.	0.766	0.13500×10^{-5}	0.105	0.752	114.04	1.28	3.50	P	11624.00
198.0	6222.	0.008	0.22090×10^{-4}	0.108	0.754	114.04	38.72	3.48	C	285.91
201.0	6219.	0.022	0.37680×10^{-4}	0.108	0.754	114.04	25.27	3.49	C	101.90
197.5	6216.	0.041	0.52090×10^{-4}	0.108	0.754	114.04	17.09	3.49	C	66.01
192.8	6214.	0.064	0.65340×10^{-4}	0.108	0.754	114.04	12.30	3.49	C	47.84

186.6	6211.	0.096	0.80650×10^{-4}	0.108	0.754	114.04	8.77	3.49	C	33.32
182.9	6209.	0.117	0.89120×10^{-4}	0.107	0.754	114.04	7.41	3.48	C	32.01
245.1	6186.	0.180	0.16022×10^{-3}	0.106	0.753	114.04	5.07	3.49	C	24.69
263.2	6182.	0.224	0.18998×10^{-3}	0.106	0.753	114.04	4.15	3.49	C	23.91
283.7	6172.	0.317	0.24106×10^{-3}	0.106	0.753	114.04	2.99	3.50	C	20.09
293.7	6159.	0.424	0.28855×10^{-3}	0.105	0.752	114.04	2.27	3.50	C	20.70
297.2	6142.	0.554	0.33760×10^{-3}	0.104	0.752	114.04	1.75	3.50	C	20.48
296.1	6120.	0.722	0.39133×10^{-3}	0.103	0.751	114.04	1.35	3.51	C	21.38
231.9	8079.	0.008	0.21640×10^{-4}	0.106	0.753	114.04	39.13	3.50	C	215.96
211.5	8074.	0.021	0.33990×10^{-4}	0.106	0.753	114.04	26.01	3.49	C	99.02
197.2	8069.	0.038	0.45400×10^{-4}	0.106	0.753	114.04	18.08	3.49	C	60.92
185.8	8065.	0.058	0.55890×10^{-4}	0.106	0.753	114.04	13.32	3.50	C	43.67
174.5	8060.	0.086	0.68020×10^{-4}	0.106	0.753	114.04	9.71	3.50	C	29.76
168.8	8057.	0.103	0.74720×10^{-4}	0.106	0.753	114.04	8.29	3.50	C	28.21
228.9	8019.	0.157	0.13875×10^{-3}	0.104	0.751	114.04	5.73	3.51	C	20.96
248.5	8012.	0.196	0.16713×10^{-3}	0.104	0.751	114.04	4.69	3.51	C	21.38
268.8	7994.	0.279	0.21584×10^{-3}	0.103	0.751	114.04	3.38	3.51	C	17.89
277.2	7969.	0.376	0.26107×10^{-3}	0.102	0.750	114.04	2.55	3.51	C	19.01
278.8	7937.	0.496	0.30772×10^{-3}	0.101	0.749	114.04	1.95	3.52	C	18.12
275.3	7892.	0.650	0.35874×10^{-3}	0.100	0.748	114.04	1.50	3.53	C	18.80
194.3	4755.	0.008	0.23400×10^{-4}	0.107	0.754	114.04	38.94	3.49	C	1663.70
196.7	4753.	0.023	0.42060×10^{-4}	0.107	0.754	114.04	24.58	3.49	C	112.01
195.5	4751.	0.044	0.59300×10^{-4}	0.107	0.754	114.04	16.12	3.49	C	73.24
193.4	4749.	0.070	0.75170×10^{-4}	0.107	0.754	114.04	11.36	3.49	C	53.96
190.4	4748.	0.108	0.93510×10^{-4}	0.107	0.754	114.04	7.96	3.49	C	37.31
188.8	4747.	0.132	0.10365×10^{-3}	0.107	0.754	114.04	6.67	3.49	C	38.47
246.2	4736.	0.202	0.17601×10^{-3}	0.106	0.753	114.04	4.56	3.49	C	33.09
259.3	4734.	0.250	0.20361×10^{-3}	0.106	0.753	114.04	3.74	3.49	C	27.48
274.8	4729.	0.347	0.25095×10^{-3}	0.106	0.753	114.04	2.74	3.49	C	23.54
282.8	4723.	0.457	0.29501×10^{-3}	0.106	0.753	114.04	2.11	3.50	C	23.44
286.5	4715.	0.589	0.34055×10^{-3}	0.105	0.752	114.04	1.65	3.50	C	24.68
286.5	4705.	0.757	0.39052×10^{-3}	0.104	0.752	114.04	1.29	3.50	C	26.18
295.2	5846.	0.099	0.35724×10^{-3}	0.108	0.754	114.04	8.56	3.49	P	23.15
277.4	5839.	0.248	0.30111×10^{-3}	0.107	0.754	114.04	3.76	3.49	P	26.61
255.6	5830.	0.363	0.24912×10^{-3}	0.107	0.753	114.04	2.62	3.49	P	27.11
229.3	5821.	0.451	0.20121×10^{-3}	0.106	0.753	114.04	2.14	3.50	P	30.88
188.7	5809.	0.529	0.14579×10^{-3}	0.106	0.753	114.04	1.83	3.50	P	41.06
160.6	5802.	0.561	0.11508×10^{-3}	0.105	0.752	114.04	1.73	3.50	P	41.62
259.9	5735.	0.644	0.19506×10^{-3}	0.102	0.750	114.04	1.51	3.52	P	49.04
245.0	5726.	0.690	0.17095×10^{-3}	0.102	0.749	114.04	1.41	3.52	P	31.80
212.9	5711.	0.756	0.13022×10^{-3}	0.101	0.749	114.04	1.29	3.52	P	72.10
172.8	5696.	0.801	0.92210×10^{-4}	0.100	0.748	114.04	1.22	3.53	P	61.41
116.2	5681.	0.832	0.52840×10^{-4}	0.099	0.748	114.04	1.18	3.53	P	338.58
25.7	5663.	0.848	0.95500×10^{-5}	0.099	0.747	114.04	1.16	3.54	P	341.52
233.5	7771.	0.080	0.28037×10^{-3}	0.105	0.752	114.04	10.29	3.50	P	23.59
235.2	7758.	0.198	0.23962×10^{-3}	0.105	0.752	114.04	4.65	3.50	P	26.90
233.4	7742.	0.291	0.20186×10^{-3}	0.104	0.752	114.04	3.25	3.50	P	27.63
226.4	7724.	0.363	0.16707×10^{-3}	0.104	0.751	114.04	2.63	3.51	P	30.59
209.1	7699.	0.430	0.12683×10^{-3}	0.103	0.750	114.04	2.24	3.51	P	37.55

192.9	7683.	0.459	0.10452×10^{-3}	0.102	0.750	114.04	2.10	3.52	P	38.81
345.7	7520.	0.551	0.21719×10^{-3}	0.096	0.745	114.04	1.76	3.55	P	34.79
335.1	7497.	0.604	0.19465×10^{-3}	0.096	0.744	114.04	1.61	3.55	P	27.11
304.7	7455.	0.681	0.15722×10^{-3}	0.094	0.743	114.04	1.44	3.56	P	45.52
259.7	7411.	0.739	0.12228×10^{-3}	0.093	0.742	114.04	1.33	3.58	P	44.82
195.5	7362.	0.785	0.86130×10^{-4}	0.091	0.740	114.04	1.25	3.58	P	93.17
108.8	7302.	0.819	0.46450×10^{-4}	0.089	0.739	114.04	1.20	3.60	P	99.23
269.1	4419.	0.101	0.36479×10^{-3}	0.107	0.754	114.04	8.39	3.49	P	27.27
263.3	4416.	0.254	0.31043×10^{-3}	0.107	0.754	114.04	3.68	3.49	P	32.94
254.0	4411.	0.373	0.26009×10^{-3}	0.107	0.754	114.04	2.56	3.49	P	35.50
240.8	4407.	0.465	0.21372×10^{-3}	0.107	0.753	114.04	2.07	3.49	P	38.96
216.6	4401.	0.548	0.16005×10^{-3}	0.106	0.753	114.04	1.77	3.49	P	49.36
197.5	4397.	0.584	0.13031×10^{-3}	0.106	0.753	114.04	1.66	3.49	P	50.84
379.5	4362.	0.682	0.24371×10^{-3}	0.104	0.751	114.04	1.43	3.51	P	58.23
373.9	4356.	0.740	0.21376×10^{-3}	0.103	0.751	114.04	1.32	3.51	P	40.38
358.5	4348.	0.821	0.16294×10^{-3}	0.103	0.750	114.04	1.19	3.52	P	78.60
332.3	4340.	0.877	0.11550×10^{-3}	0.102	0.750	114.04	1.12	3.51	P	82.87
278.9	4333.	0.916	0.66350×10^{-4}	0.102	0.750	114.04	1.07	3.52	P	649.55
102.6	4325.	0.934	0.12260×10^{-4}	0.101	0.749	114.04	1.05	3.52	P	685.47
293.7	3376.	0.101	0.35901×10^{-3}	0.108	0.754	114.04	8.41	3.49	P	34.24
281.3	3374.	0.250	0.30220×10^{-3}	0.108	0.754	114.04	3.73	3.49	P	44.32
265.3	3372.	0.365	0.24960×10^{-3}	0.108	0.754	114.04	2.61	3.49	P	48.60
244.9	3370.	0.452	0.20115×10^{-3}	0.107	0.754	114.04	2.13	3.49	P	52.15
211.7	3368.	0.529	0.14507×10^{-3}	0.107	0.754	114.04	1.83	3.49	P	69.53
186.5	3367.	0.561	0.11401×10^{-3}	0.107	0.754	114.04	1.73	3.49	P	71.46
412.3	3352.	0.651	0.23299×10^{-3}	0.106	0.753	114.04	1.50	3.50	P	93.56
406.1	3350.	0.705	0.20237×10^{-3}	0.106	0.753	114.04	1.38	3.50	P	55.55
390.5	3346.	0.781	0.15014×10^{-3}	0.105	0.752	114.04	1.25	3.50	P	115.79
363.5	3343.	0.832	0.10139×10^{-3}	0.105	0.752	114.04	1.18	3.50	P	120.95
299.4	3340.	0.863	0.50840×10^{-4}	0.105	0.752	114.04	1.14	3.50	P	1016.56
253.4	3424.	0.015	0.31920×10^{-4}	0.108	0.755	114.04	30.61	3.48	C	294.07
223.3	3423.	0.032	0.51170×10^{-4}	0.108	0.755	114.04	19.94	3.48	C	141.99
212.3	3422.	0.055	0.68890×10^{-4}	0.108	0.755	114.04	13.64	3.48	C	121.73
205.7	3422.	0.091	0.89370×10^{-4}	0.108	0.755	114.04	9.22	3.48	C	114.49
203.2	3421.	0.114	0.10071×10^{-3}	0.108	0.755	114.04	7.58	3.48	C	111.43
192.5	3417.	0.171	0.12643×10^{-3}	0.108	0.754	114.04	5.31	3.49	C	49.83
207.2	3416.	0.205	0.15019×10^{-3}	0.108	0.754	114.04	4.49	3.49	C	38.10
225.8	3415.	0.278	0.19093×10^{-3}	0.108	0.754	114.04	3.38	3.49	C	31.43
237.4	3413.	0.362	0.22888×10^{-3}	0.107	0.754	114.04	2.63	3.49	C	30.59
245.9	3411.	0.465	0.26818×10^{-3}	0.107	0.754	114.04	2.07	3.49	C	31.41
252.0	3408.	0.598	0.31136×10^{-3}	0.107	0.754	114.04	1.62	3.49	C	33.08

APPENDIX A2

Convective boiling of R134a within a micro-fin tube
(file: TaevapGWP3b.dat)

Nu	Re	x_q	Bo	P_s/P_c	T_s/T_c	M_w	Sv	Pr	flow	U_{Nu}
133.1	4663.	0.004	0.14900×10^{-4}	0.087	0.744	102.03	55.99	3.77	C	398.42
157.2	4660.	0.015	0.30240×10^{-4}	0.087	0.744	102.03	35.37	3.77	C	101.87
163.0	4658.	0.030	0.44430×10^{-4}	0.087	0.744	102.03	22.70	3.77	C	66.86
163.5	4657.	0.050	0.57480×10^{-4}	0.087	0.744	102.03	15.68	3.77	C	48.14
161.8	4655.	0.079	0.72560×10^{-4}	0.086	0.744	102.03	10.77	3.77	C	33.21
160.1	4653.	0.098	0.80890×10^{-4}	0.086	0.743	102.03	8.94	3.77	C	33.43
204.1	4639.	0.153	0.13625×10^{-3}	0.086	0.743	102.03	6.02	3.78	C	26.39
216.6	4637.	0.190	0.15911×10^{-3}	0.086	0.743	102.03	4.92	3.78	C	25.29
230.1	4631.	0.267	0.19834×10^{-3}	0.085	0.742	102.03	3.57	3.78	C	20.82
235.9	4623.	0.354	0.23484×10^{-3}	0.085	0.742	102.03	2.72	3.78	C	21.44
237.4	4613.	0.460	0.27255×10^{-3}	0.084	0.742	102.03	2.11	3.79	C	21.66
235.6	4598.	0.594	0.31388×10^{-3}	0.084	0.741	102.03	1.65	3.79	C	22.25
60.9	6533.	0.001	0.10080×10^{-4}	0.086	0.744	102.03	69.50	3.77	C	326.94
106.8	6529.	0.008	0.22040×10^{-4}	0.086	0.744	102.03	45.62	3.77	C	74.10
130.8	6525.	0.020	0.33090×10^{-4}	0.086	0.743	102.03	29.67	3.77	C	56.14
142.5	6521.	0.035	0.43250×10^{-4}	0.086	0.743	102.03	20.56	3.77	C	42.45
148.3	6517.	0.057	0.54990×10^{-4}	0.086	0.743	102.03	14.13	3.78	C	30.13
148.9	6514.	0.072	0.61480×10^{-4}	0.086	0.743	102.03	11.73	3.77	C	29.74
209.1	6483.	0.117	0.11548×10^{-3}	0.085	0.742	102.03	7.66	3.79	C	22.59
222.8	6478.	0.149	0.13504×10^{-3}	0.085	0.742	102.03	6.17	3.79	C	22.46
235.3	6464.	0.215	0.16865×10^{-3}	0.084	0.741	102.03	4.39	3.79	C	18.80
238.4	6445.	0.290	0.19987×10^{-3}	0.083	0.741	102.03	3.30	3.79	C	19.37
235.8	6419.	0.381	0.23207×10^{-3}	0.082	0.740	102.03	2.54	3.80	C	19.29
228.8	6383.	0.497	0.26729×10^{-3}	0.081	0.739	102.03	1.96	3.81	C	19.52
269.1	4443.	0.007	0.18450×10^{-4}	0.086	0.743	102.03	48.89	3.78	C	18029.05
204.7	4441.	0.019	0.33490×10^{-4}	0.086	0.743	102.03	30.86	3.78	C	132.38
184.7	4439.	0.036	0.47400×10^{-4}	0.086	0.743	102.03	20.21	3.78	C	76.51
173.9	4437.	0.057	0.60190×10^{-4}	0.086	0.743	102.03	14.22	3.78	C	52.46
164.8	4435.	0.087	0.74980×10^{-4}	0.086	0.743	102.03	9.94	3.78	C	35.59
160.7	4433.	0.107	0.83150×10^{-4}	0.085	0.743	102.03	8.32	3.78	C	34.71
214.6	4418.	0.165	0.14956×10^{-3}	0.085	0.742	102.03	5.60	3.79	C	28.26
224.9	4416.	0.206	0.17298×10^{-3}	0.085	0.742	102.03	4.57	3.79	C	25.79
235.5	4410.	0.289	0.21320×10^{-3}	0.084	0.742	102.03	3.31	3.79	C	22.06
239.8	4402.	0.382	0.25060×10^{-3}	0.084	0.741	102.03	2.53	3.79	C	22.36
240.8	4391.	0.495	0.28924×10^{-3}	0.083	0.741	102.03	1.97	3.80	C	23.63
238.6	4377.	0.637	0.33159×10^{-3}	0.083	0.740	102.03	1.54	3.80	C	24.56
109.3	6116.	0.005	0.11080×10^{-4}	0.087	0.744	102.03	52.96	3.77	C	357.04
143.9	6112.	0.013	0.23470×10^{-4}	0.087	0.744	102.03	37.13	3.77	C	100.65
153.9	6109.	0.026	0.34910×10^{-4}	0.087	0.744	102.03	25.41	3.77	C	66.61
156.1	6106.	0.041	0.45450×10^{-4}	0.087	0.744	102.03	18.18	3.77	C	47.06
154.7	6103.	0.065	0.57610×10^{-4}	0.087	0.744	102.03	12.79	3.77	C	32.50

152.9	6100.	0.080	0.64340×10^{-4}	0.086	0.744	102.03	10.71	3.77	C	31.34
208.4	6073.	0.127	0.11932×10^{-3}	0.085	0.743	102.03	7.14	3.78	C	23.22
222.2	6068.	0.159	0.14043×10^{-3}	0.085	0.743	102.03	5.79	3.78	C	23.49
236.2	6057.	0.228	0.17669×10^{-3}	0.085	0.742	102.03	4.14	3.78	C	19.64
241.1	6041.	0.306	0.21038×10^{-3}	0.084	0.742	102.03	3.13	3.79	C	20.77
241.0	6020.	0.402	0.24516×10^{-3}	0.083	0.741	102.03	2.41	3.79	C	20.16
236.7	5990.	0.524	0.28322×10^{-3}	0.082	0.740	102.03	1.86	3.80	C	20.77
169.5	3742.	0.032	0.48680×10^{-4}	0.086	0.743	102.03	21.83	3.77	C	77.24
168.8	3741.	0.054	0.63820×10^{-4}	0.086	0.743	102.03	14.80	3.77	C	54.55
166.6	3739.	0.086	0.81310×10^{-4}	0.086	0.743	102.03	10.01	3.78	C	37.44
165.1	3739.	0.108	0.90990×10^{-4}	0.086	0.743	102.03	8.25	3.78	C	37.84
196.5	3728.	0.166	0.14397×10^{-3}	0.085	0.743	102.03	5.56	3.78	C	29.70
207.8	3727.	0.205	0.16761×10^{-3}	0.085	0.742	102.03	4.57	3.78	C	27.69
220.4	3723.	0.286	0.20819×10^{-3}	0.085	0.742	102.03	3.34	3.78	C	23.26
227.0	3718.	0.377	0.24596×10^{-3}	0.085	0.742	102.03	2.56	3.79	C	23.54
229.8	3712.	0.488	0.28501×10^{-3}	0.084	0.742	102.03	2.00	3.79	C	24.23
230.0	3704.	0.628	0.32787×10^{-3}	0.084	0.741	102.03	1.56	3.79	C	25.13
2717.6	2600.	0.006	0.15280×10^{-4}	0.085	0.742	102.03	51.28	3.78	C	
256.1	2599.	0.017	0.33060×10^{-4}	0.085	0.742	102.03	32.72	3.78	C	231.94
203.2	2598.	0.035	0.49490×10^{-4}	0.085	0.742	102.03	20.88	3.79	C	115.46
184.9	2597.	0.057	0.64610×10^{-4}	0.085	0.742	102.03	14.31	3.79	C	77.06
173.8	2597.	0.089	0.82100×10^{-4}	0.085	0.742	102.03	9.75	3.79	C	51.71
169.7	2597.	0.111	0.91770×10^{-4}	0.085	0.742	102.03	8.07	3.79	C	52.52
164.4	2592.	0.163	0.11945×10^{-3}	0.084	0.742	102.03	5.66	3.79	C	40.72
173.5	2592.	0.196	0.13912×10^{-3}	0.084	0.741	102.03	4.78	3.79	C	35.19
184.9	2590.	0.263	0.17287×10^{-3}	0.084	0.741	102.03	3.62	3.79	C	29.91
192.2	2589.	0.338	0.20431×10^{-3}	0.084	0.741	102.03	2.85	3.79	C	28.86
197.1	2587.	0.430	0.23687×10^{-3}	0.084	0.741	102.03	2.26	3.79	C	30.09
200.7	2585.	0.546	0.27264×10^{-3}	0.084	0.741	102.03	1.79	3.79	C	31.52
203.0	4487.	0.080	0.29746×10^{-3}	0.087	0.744	102.03	10.70	3.77	P	20.47
204.6	4482.	0.205	0.25646×10^{-3}	0.087	0.744	102.03	4.57	3.77	P	25.06
204.2	4476.	0.304	0.21847×10^{-3}	0.087	0.744	102.03	3.14	3.77	P	26.62
200.9	4470.	0.382	0.18348×10^{-3}	0.086	0.744	102.03	2.53	3.77	P	29.26
191.9	4460.	0.455	0.14299×10^{-3}	0.086	0.743	102.03	2.13	3.78	P	36.80
182.9	4454.	0.488	0.12054×10^{-3}	0.086	0.743	102.03	1.99	3.78	P	38.13
297.9	4394.	0.574	0.20001×10^{-3}	0.082	0.740	102.03	1.70	3.80	P	40.21
299.5	4386.	0.622	0.17898×10^{-3}	0.082	0.740	102.03	1.57	3.81	P	30.96
296.8	4371.	0.692	0.14361×10^{-3}	0.081	0.739	102.03	1.42	3.81	P	55.96
284.6	4357.	0.744	0.11059×10^{-3}	0.081	0.738	102.03	1.32	3.81	P	58.14
254.8	4342.	0.784	0.76390×10^{-4}	0.080	0.737	102.03	1.26	3.82	P	125.23
180.1	4323.	0.811	0.38790×10^{-4}	0.079	0.737	102.03	1.21	3.83	P	149.37
251.0	3457.	0.099	0.35443×10^{-3}	0.087	0.744	102.03	8.85	3.77	P	23.52
246.9	3454.	0.248	0.30309×10^{-3}	0.087	0.744	102.03	3.83	3.77	P	28.93
239.9	3451.	0.365	0.25555×10^{-3}	0.086	0.743	102.03	2.64	3.77	P	30.85
230.2	3447.	0.455	0.21175×10^{-3}	0.086	0.743	102.03	2.14	3.78	P	33.89
212.1	3442.	0.538	0.16105×10^{-3}	0.086	0.743	102.03	1.81	3.78	P	42.80
197.5	3439.	0.574	0.13296×10^{-3}	0.085	0.743	102.03	1.70	3.78	P	44.48
339.4	3410.	0.665	0.21581×10^{-3}	0.084	0.741	102.03	1.47	3.79	P	51.88
341.7	3406.	0.716	0.18946×10^{-3}	0.083	0.741	102.03	1.37	3.80	P	40.42

347.1	3400.	0.788	0.14474×10^{-3}	0.083	0.740	102.03	1.25	3.80	P	75.81
356.1	3394.	0.838	0.10299×10^{-3}	0.082	0.740	102.03	1.18	3.80	P	90.02
381.4	3388.	0.872	0.59730×10^{-4}	0.082	0.740	102.03	1.13	3.80	P	455.08
201.7	6619.	0.061	0.21101×10^{-3}	0.085	0.742	102.03	13.40	3.78	P	21.27
205.5	6608.	0.150	0.18086×10^{-3}	0.085	0.742	102.03	6.11	3.79	P	25.65
205.8	6594.	0.221	0.15293×10^{-3}	0.084	0.742	102.03	4.27	3.79	P	26.96
202.1	6579.	0.276	0.12719×10^{-3}	0.084	0.741	102.03	3.46	3.79	P	29.87
189.6	6557.	0.327	0.97420×10^{-4}	0.083	0.740	102.03	2.94	3.80	P	37.26
177.1	6544.	0.350	0.80920×10^{-4}	0.082	0.740	102.03	2.76	3.80	P	38.59
291.9	6400.	0.419	0.15969×10^{-3}	0.077	0.735	102.03	2.32	3.84	P	34.36
284.7	6380.	0.459	0.14474×10^{-3}	0.077	0.735	102.03	2.12	3.85	P	26.14
261.6	6342.	0.518	0.11999×10^{-3}	0.076	0.733	102.03	1.89	3.86	P	41.69
226.5	6303.	0.563	0.96880×10^{-4}	0.074	0.732	102.03	1.74	3.86	P	41.05
177.4	6258.	0.601	0.72980×10^{-4}	0.073	0.731	102.03	1.63	3.88	P	72.56
113.2	6204.	0.631	0.46730×10^{-4}	0.071	0.729	102.03	1.56	3.90	P	76.08
215.3	2561.	0.092	0.32972×10^{-3}	0.086	0.743	102.03	9.45	3.77	P	30.00
209.0	2560.	0.230	0.28109×10^{-3}	0.086	0.743	102.03	4.11	3.78	P	39.99
200.6	2559.	0.338	0.23607×10^{-3}	0.086	0.743	102.03	2.84	3.78	P	44.17
189.6	2557.	0.421	0.19460×10^{-3}	0.086	0.743	102.03	2.30	3.78	P	44.60
171.3	2555.	0.497	0.14660×10^{-3}	0.086	0.743	102.03	1.96	3.78	P	57.57
157.2	2554.	0.530	0.12001×10^{-3}	0.085	0.743	102.03	1.84	3.78	P	59.18
304.4	2543.	0.614	0.20722×10^{-3}	0.084	0.742	102.03	1.59	3.78	P	80.31
304.8	2541.	0.663	0.18151×10^{-3}	0.084	0.742	102.03	1.48	3.79	P	50.36
304.2	2538.	0.731	0.13763×10^{-3}	0.084	0.741	102.03	1.34	3.79	P	106.40
301.2	2536.	0.778	0.96670×10^{-4}	0.084	0.741	102.03	1.26	3.79	P	110.90
290.7	2533.	0.810	0.54220×10^{-4}	0.084	0.741	102.03	1.22	3.79	P	1183.37
183.9	2530.	0.824	0.74700×10^{-5}	0.083	0.741	102.03	1.19	3.80	P	1423.46
210.2	4564.	0.080	0.28853×10^{-3}	0.086	0.743	102.03	10.73	3.78	P	20.77
210.4	4559.	0.201	0.24748×10^{-3}	0.086	0.743	102.03	4.66	3.78	P	25.49
208.3	4553.	0.297	0.20945×10^{-3}	0.085	0.743	102.03	3.22	3.78	P	27.12
202.8	4545.	0.371	0.17441×10^{-3}	0.085	0.742	102.03	2.60	3.78	P	29.90
190.2	4535.	0.440	0.13387×10^{-3}	0.085	0.742	102.03	2.20	3.79	P	38.15
178.5	4529.	0.471	0.11140×10^{-3}	0.084	0.742	102.03	2.06	3.79	P	39.48
294.7	4464.	0.553	0.19273×10^{-3}	0.081	0.739	102.03	1.77	3.81	P	40.59
293.9	4455.	0.599	0.17304×10^{-3}	0.080	0.738	102.03	1.63	3.81	P	30.69
287.9	4439.	0.667	0.13999×10^{-3}	0.080	0.737	102.03	1.47	3.82	P	52.85
273.3	4424.	0.718	0.10914×10^{-3}	0.079	0.737	102.03	1.37	3.83	P	56.95
242.4	4408.	0.758	0.77190×10^{-4}	0.078	0.736	102.03	1.30	3.84	P	113.59
175.1	4389.	0.786	0.42060×10^{-4}	0.077	0.735	102.03	1.25	3.84	P	132.31
207.9	4588.	0.078	0.28278×10^{-3}	0.086	0.743	102.03	10.97	3.78	P	20.89
208.4	4583.	0.196	0.24260×10^{-3}	0.086	0.743	102.03	4.76	3.78	P	25.74
206.5	4577.	0.290	0.20538×10^{-3}	0.085	0.743	102.03	3.29	3.78	P	27.41
201.3	4570.	0.363	0.17109×10^{-3}	0.085	0.742	102.03	2.65	3.78	P	30.23
189.0	4560.	0.431	0.13141×10^{-3}	0.085	0.742	102.03	2.25	3.79	P	38.56
177.6	4554.	0.461	0.10942×10^{-3}	0.084	0.742	102.03	2.11	3.79	P	39.90
296.0	4490.	0.542	0.19009×10^{-3}	0.081	0.739	102.03	1.80	3.81	P	41.15
295.3	4481.	0.588	0.17050×10^{-3}	0.081	0.738	102.03	1.67	3.82	P	30.97
288.0	4465.	0.655	0.13758×10^{-3}	0.080	0.737	102.03	1.50	3.82	P	53.24
271.6	4450.	0.705	0.10685×10^{-3}	0.079	0.737	102.03	1.39	3.83	P	57.33

237.7	4433.	0.744	0.75030×10^{-4}	0.078	0.736	102.03	1.32	3.83	P	118.46
165.6	4413.	0.771	0.40050×10^{-4}	0.077	0.735	102.03	1.28	3.84	P	135.52
205.5	6692.	0.062	0.21494×10^{-3}	0.087	0.744	102.03	13.19	3.77	P	20.72
207.8	6681.	0.153	0.18321×10^{-3}	0.086	0.743	102.03	6.02	3.77	P	25.13
206.7	6667.	0.224	0.15382×10^{-3}	0.086	0.743	102.03	4.21	3.78	P	26.53
201.1	6652.	0.279	0.12675×10^{-3}	0.085	0.742	102.03	3.42	3.78	P	29.47
185.6	6630.	0.329	0.95440×10^{-4}	0.084	0.742	102.03	2.92	3.79	P	37.34
171.0	6616.	0.352	0.78080×10^{-4}	0.084	0.741	102.03	2.74	3.79	P	38.64
285.3	6471.	0.420	0.15624×10^{-3}	0.079	0.737	102.03	2.31	3.83	P	33.91
279.4	6450.	0.458	0.14235×10^{-3}	0.078	0.736	102.03	2.13	3.83	P	25.96
259.1	6411.	0.516	0.11941×10^{-3}	0.077	0.735	102.03	1.89	3.85	P	40.45
227.0	6371.	0.562	0.97980×10^{-4}	0.076	0.733	102.03	1.74	3.85	P	40.89
181.9	6325.	0.601	0.75820×10^{-4}	0.074	0.732	102.03	1.63	3.87	P	65.59
122.4	6269.	0.633	0.51490×10^{-4}	0.072	0.730	102.03	1.55	3.88	P	69.04
205.0	6722.	0.061	0.21176×10^{-3}	0.086	0.743	102.03	13.32	3.77	P	20.74
207.7	6711.	0.151	0.18070×10^{-3}	0.086	0.743	102.03	6.09	3.78	P	25.20
206.7	6697.	0.221	0.15191×10^{-3}	0.085	0.743	102.03	4.26	3.78	P	26.67
201.1	6681.	0.275	0.12540×10^{-3}	0.085	0.742	102.03	3.46	3.78	P	29.63
185.5	6658.	0.326	0.94740×10^{-4}	0.084	0.741	102.03	2.95	3.79	P	37.28
170.7	6643.	0.348	0.77740×10^{-4}	0.084	0.741	102.03	2.77	3.79	P	38.53
281.1	6494.	0.416	0.15513×10^{-3}	0.078	0.736	102.03	2.34	3.83	P	33.89
274.7	6474.	0.454	0.14137×10^{-3}	0.078	0.736	102.03	2.15	3.84	P	25.57
253.9	6434.	0.512	0.11865×10^{-3}	0.076	0.734	102.03	1.91	3.85	P	40.12
222.0	6394.	0.557	0.97430×10^{-4}	0.075	0.733	102.03	1.76	3.86	P	40.22
177.1	6347.	0.596	0.75490×10^{-4}	0.074	0.731	102.03	1.65	3.87	P	64.81
118.9	6290.	0.628	0.51390×10^{-4}	0.072	0.729	102.03	1.57	3.89	P	67.91
233.8	3426.	0.098	0.35223×10^{-3}	0.087	0.744	102.03	8.98	3.77	P	22.42
230.6	3423.	0.245	0.30066×10^{-3}	0.087	0.744	102.03	3.87	3.77	P	28.41
225.0	3420.	0.361	0.25290×10^{-3}	0.087	0.744	102.03	2.67	3.77	P	30.08
216.4	3416.	0.450	0.20889×10^{-3}	0.087	0.744	102.03	2.16	3.77	P	33.48
199.4	3411.	0.532	0.15796×10^{-3}	0.086	0.743	102.03	1.83	3.77	P	43.33
185.3	3408.	0.567	0.12974×10^{-3}	0.086	0.743	102.03	1.72	3.78	P	44.89
319.0	3377.	0.657	0.21363×10^{-3}	0.084	0.741	102.03	1.49	3.79	P	50.74
324.3	3373.	0.707	0.19016×10^{-3}	0.084	0.741	102.03	1.39	3.79	P	38.69
336.8	3366.	0.781	0.15038×10^{-3}	0.083	0.741	102.03	1.26	3.80	P	70.59
353.8	3360.	0.834	0.11325×10^{-3}	0.083	0.740	102.03	1.18	3.80	P	83.13
389.1	3353.	0.873	0.74780×10^{-4}	0.082	0.740	102.03	1.13	3.80	P	199.30
584.7	3347.	0.898	0.32440×10^{-4}	0.082	0.739	102.03	1.10	3.80	P	478.22
208.6	2614.	0.092	0.32725×10^{-3}	0.085	0.742	102.03	9.50	3.78	P	29.57
203.0	2612.	0.229	0.27968×10^{-3}	0.085	0.742	102.03	4.13	3.78	P	39.34
195.5	2610.	0.336	0.23563×10^{-3}	0.085	0.742	102.03	2.86	3.79	P	41.86
185.6	2609.	0.419	0.19505×10^{-3}	0.085	0.742	102.03	2.31	3.79	P	43.09
168.7	2607.	0.496	0.14810×10^{-3}	0.084	0.742	102.03	1.96	3.79	P	56.16
155.7	2605.	0.529	0.12207×10^{-3}	0.084	0.742	102.03	1.84	3.79	P	57.66
297.9	2592.	0.615	0.21037×10^{-3}	0.083	0.741	102.03	1.59	3.80	P	76.17
299.4	2590.	0.664	0.18524×10^{-3}	0.083	0.740	102.03	1.48	3.80	P	48.05
302.2	2587.	0.735	0.14239×10^{-3}	0.083	0.740	102.03	1.34	3.80	P	95.27
304.8	2584.	0.784	0.10239×10^{-3}	0.082	0.740	102.03	1.25	3.80	P	109.44
309.4	2581.	0.818	0.60930×10^{-4}	0.082	0.740	102.03	1.20	3.80	P	523.11

328.8	2578.	0.836	0.15280×10^{-4}	0.082	0.739	102.03	1.18	3.80	P	867.70
189.8	4689.	0.005	0.13790×10^{-4}	0.086	0.743	102.03	52.62	3.78	C	412.85
174.7	4687.	0.015	0.28230×10^{-4}	0.086	0.743	102.03	34.81	3.78	C	122.52
166.9	4685.	0.030	0.41580×10^{-4}	0.086	0.743	102.03	22.99	3.77	C	73.85
161.1	4683.	0.049	0.53860×10^{-4}	0.086	0.743	102.03	16.12	3.78	C	51.54
155.4	4680.	0.076	0.68050×10^{-4}	0.086	0.743	102.03	11.20	3.78	C	34.23
152.4	4679.	0.094	0.75900×10^{-4}	0.086	0.743	102.03	9.34	3.78	C	35.58
192.0	4664.	0.145	0.12844×10^{-3}	0.085	0.742	102.03	6.33	3.78	C	23.82
209.0	4661.	0.180	0.15441×10^{-3}	0.085	0.742	102.03	5.17	3.79	C	24.43
228.3	4655.	0.256	0.19898×10^{-3}	0.084	0.742	102.03	3.71	3.79	C	20.97
238.6	4646.	0.345	0.24043×10^{-3}	0.084	0.741	102.03	2.79	3.79	C	22.61
243.5	4635.	0.454	0.28326×10^{-3}	0.083	0.741	102.03	2.14	3.80	C	21.43
244.5	4619.	0.595	0.33021×10^{-3}	0.083	0.740	102.03	1.64	3.80	C	22.69
138.4	6314.	0.005	0.11290×10^{-4}	0.086	0.743	102.03	54.25	3.78	C	525.74
154.3	6310.	0.013	0.22830×10^{-4}	0.086	0.743	102.03	37.84	3.78	C	106.34
154.9	6307.	0.025	0.33500×10^{-4}	0.086	0.743	102.03	26.01	3.78	C	66.41
151.9	6303.	0.040	0.43310×10^{-4}	0.085	0.743	102.03	18.71	3.78	C	46.41
147.0	6299.	0.062	0.54650×10^{-4}	0.085	0.743	102.03	13.25	3.78	C	31.20
144.0	6297.	0.076	0.60920×10^{-4}	0.085	0.742	102.03	11.13	3.78	C	30.74
191.0	6267.	0.120	0.11148×10^{-3}	0.084	0.741	102.03	7.49	3.79	C	21.03
207.8	6262.	0.151	0.13432×10^{-3}	0.084	0.741	102.03	6.08	3.79	C	22.14
225.3	6250.	0.218	0.17353×10^{-3}	0.083	0.741	102.03	4.33	3.79	C	18.72
232.5	6232.	0.296	0.20995×10^{-3}	0.083	0.740	102.03	3.24	3.80	C	20.96
233.9	6208.	0.392	0.24754×10^{-3}	0.082	0.739	102.03	2.47	3.81	C	18.93
230.6	6173.	0.516	0.28866×10^{-3}	0.081	0.738	102.03	1.89	3.82	C	19.93
241.1	6329.	0.006	0.13200×10^{-4}	0.085	0.742	102.03	50.80	3.78	C	813.70
192.8	6325.	0.015	0.24240×10^{-4}	0.085	0.742	102.03	35.14	3.78	C	123.85
173.6	6321.	0.028	0.34450×10^{-4}	0.085	0.742	102.03	24.38	3.78	C	70.65
161.5	6317.	0.043	0.43840×10^{-4}	0.085	0.742	102.03	17.75	3.79	C	47.55
150.7	6312.	0.065	0.54680×10^{-4}	0.085	0.742	102.03	12.73	3.79	C	31.77
145.4	6310.	0.080	0.60680×10^{-4}	0.084	0.742	102.03	10.76	3.78	C	30.14
188.8	6277.	0.123	0.11056×10^{-3}	0.083	0.741	102.03	7.33	3.80	C	20.76
205.2	6272.	0.154	0.13369×10^{-3}	0.083	0.740	102.03	5.98	3.80	C	21.94
222.6	6259.	0.221	0.17342×10^{-3}	0.083	0.740	102.03	4.28	3.80	C	18.36
229.4	6240.	0.299	0.21032×10^{-3}	0.082	0.739	102.03	3.21	3.81	C	20.65
230.3	6214.	0.395	0.24839×10^{-3}	0.081	0.739	102.03	2.45	3.81	C	18.42
226.8	6177.	0.520	0.29003×10^{-3}	0.080	0.737	102.03	1.88	3.82	C	19.37
364.2	3919.	0.006	0.16470×10^{-4}	0.085	0.742	102.03	51.31	3.79	C	681.75
218.4	3917.	0.017	0.32060×10^{-4}	0.084	0.742	102.03	32.61	3.78	C	155.91
189.7	3915.	0.034	0.46460×10^{-4}	0.084	0.742	102.03	21.18	3.79	C	85.62
176.4	3914.	0.054	0.59710×10^{-4}	0.084	0.742	102.03	14.76	3.79	C	58.67
166.2	3912.	0.085	0.75020×10^{-4}	0.084	0.742	102.03	10.22	3.79	C	38.80
161.9	3912.	0.104	0.83490×10^{-4}	0.084	0.742	102.03	8.52	3.79	C	40.12
199.3	3901.	0.160	0.13891×10^{-3}	0.084	0.741	102.03	5.78	3.79	C	31.04
209.5	3899.	0.197	0.16156×10^{-3}	0.083	0.741	102.03	4.75	3.79	C	26.96
220.5	3895.	0.275	0.20043×10^{-3}	0.083	0.741	102.03	3.47	3.80	C	23.26
225.4	3890.	0.363	0.23660×10^{-3}	0.083	0.740	102.03	2.66	3.80	C	23.16
227.0	3883.	0.469	0.27399×10^{-3}	0.082	0.740	102.03	2.07	3.80	C	24.00
226.3	3873.	0.604	0.31502×10^{-3}	0.082	0.739	102.03	1.62	3.81	C	25.21

11820.4	2669.	0.006	0.14700×10^{-4}	0.085	0.743	102.03	51.42	3.78	C	28246.61
254.3	2668.	0.017	0.31810×10^{-4}	0.085	0.743	102.03	33.22	3.78	C	299.04
198.1	2667.	0.033	0.47630×10^{-4}	0.085	0.743	102.03	21.37	3.78	C	136.65
178.9	2667.	0.055	0.62180×10^{-4}	0.085	0.743	102.03	14.71	3.78	C	114.31
167.3	2666.	0.086	0.79000×10^{-4}	0.085	0.742	102.03	10.06	3.78	C	108.39
163.1	2666.	0.107	0.88310×10^{-4}	0.085	0.742	102.03	8.33	3.78	C	105.42
164.9	2661.	0.158	0.11981×10^{-3}	0.085	0.742	102.03	5.82	3.78	C	40.16
175.0	2661.	0.191	0.14029×10^{-3}	0.085	0.742	102.03	4.89	3.78	C	34.23
187.6	2660.	0.259	0.17541×10^{-3}	0.085	0.742	102.03	3.68	3.79	C	29.38
195.5	2658.	0.335	0.20813×10^{-3}	0.085	0.742	102.03	2.87	3.79	C	28.81
200.8	2656.	0.429	0.24200×10^{-3}	0.084	0.742	102.03	2.26	3.79	C	29.58
204.6	2654.	0.548	0.27922×10^{-3}	0.084	0.742	102.03	1.78	3.79	C	31.31

APPENDIX A3

Convective boiling of R450A within a micro-fin tube
(file: TaevapGWP3b.dat)

Nu	Re	x_q	Bo	P_s/P_c	T_s/T_c	M_w	Sv	Pr	flow	U_{Nu}
83.9	4738.	0.001	0.13060×10^{-4}	0.080	0.735	108.67	69.85	3.95	C	200.01
116.4	4737.	0.011	0.31050×10^{-4}	0.080	0.735	108.67	41.12	3.95	C	94.01
126.1	4737.	0.028	0.47670×10^{-4}	0.080	0.735	108.67	24.53	3.95	C	55.34
129.3	4736.	0.049	0.62970×10^{-4}	0.080	0.735	108.67	16.12	3.95	C	38.30
129.7	4736.	0.081	0.80640×10^{-4}	0.080	0.735	108.67	10.64	3.95	C	27.46
129.2	4735.	0.102	0.90420×10^{-4}	0.080	0.735	108.67	8.69	3.95	C	24.05
178.6	4722.	0.164	0.16230×10^{-3}	0.079	0.734	108.67	5.66	3.96	C	19.21
200.0	4721.	0.209	0.19995×10^{-3}	0.079	0.734	108.67	4.51	3.96	C	21.52
225.5	4715.	0.309	0.26452×10^{-3}	0.078	0.734	108.67	3.11	3.96	C	18.41
239.8	4705.	0.428	0.32466×10^{-3}	0.078	0.734	108.67	2.27	3.97	C	22.53
247.8	4692.	0.576	0.38685×10^{-3}	0.077	0.733	108.67	1.70	3.97	C	19.46
251.0	4672.	0.770	0.45512×10^{-3}	0.076	0.732	108.67	1.28	3.99	C	21.35
74.4	6986.	0.000	0.69400×10^{-5}	0.079	0.734	108.67	77.22	3.95	C	212.40
115.8	6985.	0.006	0.18490×10^{-4}	0.079	0.734	108.67	53.23	3.95	C	101.94
126.5	6983.	0.016	0.29170×10^{-4}	0.079	0.734	108.67	34.67	3.95	C	57.16
128.3	6981.	0.029	0.39000×10^{-4}	0.079	0.734	108.67	23.78	3.95	C	39.43
126.4	6978.	0.049	0.50340×10^{-4}	0.078	0.734	108.67	16.11	3.96	C	27.59
124.4	6977.	0.063	0.56620×10^{-4}	0.078	0.734	108.67	13.27	3.96	C	23.95
203.6	6948.	0.109	0.12615×10^{-3}	0.077	0.733	108.67	8.25	3.97	C	26.35
219.3	6944.	0.143	0.15091×10^{-3}	0.077	0.733	108.67	6.41	3.97	C	21.90
234.2	6931.	0.218	0.19340×10^{-3}	0.077	0.732	108.67	4.34	3.97	C	16.77
238.6	6908.	0.305	0.23289×10^{-3}	0.076	0.732	108.67	3.15	3.98	C	17.86
236.7	6875.	0.412	0.27364×10^{-3}	0.075	0.731	108.67	2.36	3.99	C	16.82
230.1	6826.	0.550	0.31821×10^{-3}	0.073	0.729	108.67	1.78	4.01	C	17.40
70.1	3760.	0.004	0.12880×10^{-4}	0.079	0.734	108.67	60.26	3.95	C	253.69
105.4	3760.	0.014	0.31320×10^{-4}	0.079	0.734	108.67	37.58	3.95	C	94.11
119.1	3759.	0.030	0.48350×10^{-4}	0.079	0.734	108.67	23.13	3.96	C	58.05
125.5	3759.	0.052	0.64030×10^{-4}	0.079	0.734	108.67	15.44	3.96	C	41.53
129.4	3759.	0.084	0.82150×10^{-4}	0.079	0.734	108.67	10.29	3.96	C	31.09
130.6	3759.	0.106	0.92180×10^{-4}	0.079	0.734	108.67	8.43	3.96	C	28.12
208.4	3752.	0.175	0.18658×10^{-3}	0.078	0.734	108.67	5.33	3.96	C	35.58
221.7	3751.	0.225	0.21606×10^{-3}	0.078	0.734	108.67	4.21	3.96	C	26.90
237.1	3749.	0.329	0.26662×10^{-3}	0.078	0.733	108.67	2.93	3.96	C	23.93
245.3	3744.	0.445	0.31374×10^{-3}	0.077	0.733	108.67	2.18	3.97	C	24.74
248.9	3736.	0.586	0.36249×10^{-3}	0.077	0.733	108.67	1.67	3.98	C	26.44
249.0	3725.	0.765	0.41602×10^{-3}	0.076	0.732	108.67	1.29	3.99	C	28.69
44.3	2104.	0.005	0.16360×10^{-4}	0.079	0.734	108.67	57.39	3.95	C	784.99
71.8	2104.	0.016	0.35940×10^{-4}	0.079	0.734	108.67	34.25	3.95	C	78.42
87.2	2104.	0.035	0.54050×10^{-4}	0.079	0.734	108.67	20.88	3.96	C	57.50
97.0	2104.	0.059	0.70720×10^{-4}	0.079	0.734	108.67	13.93	3.95	C	45.47
105.6	2105.	0.094	0.89990×10^{-4}	0.079	0.734	108.67	9.32	3.95	C	35.81
109.3	2105.	0.118	0.10066×10^{-3}	0.079	0.734	108.67	7.65	3.95	C	34.24

164.7	2103.	0.188	0.18060×10^{-3}	0.078	0.734	108.67	4.98	3.96	C	56.51
172.0	2103.	0.236	0.20089×10^{-3}	0.078	0.734	108.67	4.03	3.96	C	33.87
181.7	2103.	0.329	0.23568×10^{-3}	0.078	0.734	108.67	2.93	3.96	C	30.41
188.7	2103.	0.430	0.26814×10^{-3}	0.078	0.734	108.67	2.26	3.97	C	31.69
194.0	2102.	0.548	0.30178×10^{-3}	0.078	0.734	108.67	1.78	3.97	C	35.55
198.4	2101.	0.695	0.33880×10^{-3}	0.077	0.734	108.67	1.41	3.97	C	41.65
140.2	4842.	0.003	0.12390×10^{-4}	0.079	0.734	108.67	62.36	3.96	C	349.71
140.3	4841.	0.013	0.29010×10^{-4}	0.078	0.734	108.67	39.32	3.96	C	119.96
137.2	4840.	0.028	0.44360×10^{-4}	0.078	0.734	108.67	24.52	3.96	C	64.19
133.8	4840.	0.048	0.58490×10^{-4}	0.078	0.734	108.67	16.51	3.96	C	42.22
129.8	4839.	0.077	0.74820×10^{-4}	0.078	0.734	108.67	11.08	3.96	C	29.25
127.7	4839.	0.097	0.83850×10^{-4}	0.078	0.734	108.67	9.11	3.96	C	25.35
201.4	4824.	0.161	0.17535×10^{-3}	0.077	0.733	108.67	5.77	3.97	C	25.80
217.7	4822.	0.209	0.20985×10^{-3}	0.077	0.733	108.67	4.51	3.97	C	22.79
235.8	4815.	0.312	0.26901×10^{-3}	0.077	0.733	108.67	3.08	3.97	C	18.52
244.5	4805.	0.432	0.32410×10^{-3}	0.076	0.732	108.67	2.25	3.98	C	20.16
247.9	4789.	0.579	0.38104×10^{-3}	0.075	0.732	108.67	1.69	3.99	C	19.74
247.3	4767.	0.769	0.44350×10^{-3}	0.074	0.731	108.67	1.28	4.00	C	21.17
88.2	6915.	0.001	0.73400×10^{-5}	0.079	0.734	108.67	73.35	3.95	C	246.21
118.9	6913.	0.007	0.18290×10^{-4}	0.079	0.734	108.67	51.16	3.95	C	108.92
124.7	6911.	0.017	0.28410×10^{-4}	0.079	0.734	108.67	33.98	3.95	C	60.19
124.2	6909.	0.029	0.37720×10^{-4}	0.079	0.734	108.67	23.66	3.95	C	40.74
121.0	6907.	0.049	0.48480×10^{-4}	0.078	0.734	108.67	16.24	3.95	C	28.36
118.8	6905.	0.062	0.54430×10^{-4}	0.078	0.734	108.67	13.45	3.96	C	24.56
189.9	6875.	0.105	0.11914×10^{-3}	0.077	0.733	108.67	8.46	3.97	C	26.45
204.4	6871.	0.138	0.14261×10^{-3}	0.077	0.733	108.67	6.62	3.97	C	22.20
218.5	6857.	0.209	0.18288×10^{-3}	0.077	0.732	108.67	4.51	3.97	C	17.27
222.7	6835.	0.291	0.22032×10^{-3}	0.076	0.731	108.67	3.29	3.98	C	18.47
221.8	6802.	0.393	0.25894×10^{-3}	0.075	0.731	108.67	2.47	3.99	C	17.43
216.1	6756.	0.523	0.30120×10^{-3}	0.073	0.729	108.67	1.87	4.01	C	18.16
107.9	3796.	0.003	0.13940×10^{-4}	0.079	0.734	108.67	60.90	3.95	C	276.89
122.0	3796.	0.014	0.31870×10^{-4}	0.079	0.734	108.67	37.39	3.95	C	109.78
124.7	3796.	0.031	0.48450×10^{-4}	0.079	0.734	108.67	23.00	3.95	C	62.67
125.0	3796.	0.052	0.63700×10^{-4}	0.079	0.734	108.67	15.39	3.95	C	42.99
124.2	3796.	0.084	0.81340×10^{-4}	0.079	0.734	108.67	10.30	3.95	C	30.74
123.5	3796.	0.105	0.91100×10^{-4}	0.079	0.734	108.67	8.45	3.95	C	27.03
192.3	3789.	0.173	0.18290×10^{-3}	0.078	0.734	108.67	5.39	3.96	C	31.82
205.5	3788.	0.222	0.21430×10^{-3}	0.078	0.734	108.67	4.25	3.96	C	24.78
221.1	3785.	0.326	0.26813×10^{-3}	0.078	0.734	108.67	2.95	3.97	C	20.51
229.5	3781.	0.444	0.31831×10^{-3}	0.077	0.733	108.67	2.19	3.97	C	21.19
234.0	3774.	0.587	0.37024×10^{-3}	0.077	0.733	108.67	1.67	3.98	C	22.01
235.6	3763.	0.771	0.42728×10^{-3}	0.076	0.732	108.67	1.28	3.99	C	23.87
105.7	3801.	0.003	0.13850×10^{-4}	0.079	0.734	108.67	63.36	3.95	C	272.98
122.4	3801.	0.013	0.32540×10^{-4}	0.079	0.734	108.67	38.09	3.95	C	107.19
126.0	3801.	0.030	0.49820×10^{-4}	0.079	0.734	108.67	23.04	3.95	C	61.26
126.7	3801.	0.053	0.65720×10^{-4}	0.079	0.734	108.67	15.26	3.95	C	41.99
126.1	3801.	0.086	0.84100×10^{-4}	0.079	0.734	108.67	10.13	3.95	C	30.04
125.5	3801.	0.108	0.94270×10^{-4}	0.079	0.734	108.67	8.29	3.95	C	26.41
198.3	3795.	0.178	0.19105×10^{-3}	0.078	0.734	108.67	5.25	3.96	C	31.37

211.8	3795.	0.230	0.22359×10^{-3}	0.078	0.734	108.67	4.13	3.96	C	24.22
227.3	3792.	0.338	0.27940×10^{-3}	0.078	0.734	108.67	2.85	3.96	C	20.15
235.5	3788.	0.460	0.33142×10^{-3}	0.078	0.734	108.67	2.11	3.97	C	20.66
239.9	3781.	0.609	0.38525×10^{-3}	0.077	0.733	108.67	1.61	3.98	C	21.55
240.8	3770.	0.800	0.44439×10^{-3}	0.076	0.733	108.67	1.23	3.99	C	23.33
100.4	3908.	0.003	0.13800×10^{-4}	0.079	0.734	108.67	64.57	3.95	C	262.54
118.9	3908.	0.013	0.32490×10^{-4}	0.079	0.734	108.67	38.56	3.95	C	104.90
123.0	3908.	0.030	0.49780×10^{-4}	0.079	0.734	108.67	23.21	3.95	C	59.94
124.0	3908.	0.052	0.65680×10^{-4}	0.079	0.734	108.67	15.33	3.96	C	40.92
123.5	3908.	0.086	0.84070×10^{-4}	0.079	0.734	108.67	10.16	3.96	C	29.26
122.9	3908.	0.107	0.94240×10^{-4}	0.079	0.734	108.67	8.31	3.96	C	25.69
195.3	3899.	0.179	0.19442×10^{-3}	0.078	0.733	108.67	5.23	3.96	C	28.72
208.6	3898.	0.231	0.22801×10^{-3}	0.078	0.733	108.67	4.10	3.96	C	23.04
224.2	3895.	0.342	0.28564×10^{-3}	0.078	0.733	108.67	2.82	3.97	C	19.46
233.0	3890.	0.467	0.33934×10^{-3}	0.077	0.733	108.67	2.08	3.97	C	20.14
237.4	3882.	0.620	0.39492×10^{-3}	0.076	0.733	108.67	1.58	3.98	C	21.03
238.8	3871.	0.816	0.45598×10^{-3}	0.076	0.732	108.67	1.21	3.99	C	22.84
16.9	2108.	0.000	0.92800×10^{-5}	0.079	0.734	108.67	77.11	3.95	C	132.46
45.9	2109.	0.008	0.28000×10^{-4}	0.079	0.734	108.67	47.34	3.95	C	66.65
66.2	2109.	0.023	0.45330×10^{-4}	0.079	0.734	108.67	27.49	3.95	C	52.30
81.0	2109.	0.044	0.61290×10^{-4}	0.079	0.734	108.67	17.61	3.95	C	43.82
94.5	2109.	0.075	0.79730×10^{-4}	0.079	0.734	108.67	11.36	3.95	C	35.48
100.6	2109.	0.096	0.89940×10^{-4}	0.079	0.734	108.67	9.19	3.95	C	34.80
144.5	2108.	0.156	0.14968×10^{-3}	0.079	0.734	108.67	5.94	3.95	C	51.56
154.6	2108.	0.195	0.16919×10^{-3}	0.079	0.734	108.67	4.80	3.95	C	35.39
168.4	2108.	0.275	0.20263×10^{-3}	0.079	0.734	108.67	3.47	3.95	C	30.89
178.2	2107.	0.362	0.23383×10^{-3}	0.079	0.734	108.67	2.67	3.96	C	32.50
185.5	2106.	0.466	0.26617×10^{-3}	0.078	0.734	108.67	2.09	3.96	C	36.04
191.1	2105.	0.596	0.30175×10^{-3}	0.078	0.734	108.67	1.64	3.97	C	40.87
209.1	4840.	0.106	0.38569×10^{-3}	0.079	0.734	108.67	8.42	3.95	P	17.40
208.5	4837.	0.266	0.32146×10^{-3}	0.078	0.734	108.67	3.59	3.96	P	18.82
203.7	4830.	0.388	0.26185×10^{-3}	0.078	0.734	108.67	2.50	3.96	P	19.62
193.5	4820.	0.479	0.20676×10^{-3}	0.077	0.733	108.67	2.03	3.97	P	22.23
169.9	4805.	0.558	0.14289×10^{-3}	0.077	0.733	108.67	1.75	3.98	P	28.78
147.8	4795.	0.590	0.10745×10^{-3}	0.076	0.732	108.67	1.66	3.98	P	30.65
229.6	4690.	0.668	0.17764×10^{-3}	0.071	0.728	108.67	1.47	4.03	P	30.23
236.4	4677.	0.711	0.15971×10^{-3}	0.071	0.727	108.67	1.38	4.03	P	29.18
247.5	4653.	0.775	0.12986×10^{-3}	0.070	0.726	108.67	1.27	4.05	P	45.80
255.0	4628.	0.823	0.10198×10^{-3}	0.068	0.725	108.67	1.20	4.06	P	60.38
253.8	4601.	0.861	0.73090×10^{-4}	0.067	0.724	108.67	1.15	4.07	P	104.25
223.9	4569.	0.890	0.41330×10^{-4}	0.066	0.722	108.67	1.11	4.09	P	172.41
185.8	5703.	0.082	0.30680×10^{-3}	0.079	0.734	108.67	10.52	3.95	P	17.65
187.6	5697.	0.209	0.25595×10^{-3}	0.079	0.734	108.67	4.50	3.96	P	19.30
185.6	5687.	0.307	0.20876×10^{-3}	0.078	0.734	108.67	3.13	3.96	P	20.26
178.3	5674.	0.380	0.16518×10^{-3}	0.077	0.733	108.67	2.55	3.97	P	23.01
159.1	5654.	0.444	0.11468×10^{-3}	0.077	0.732	108.67	2.19	3.98	P	29.80
139.9	5640.	0.470	0.86670×10^{-4}	0.076	0.732	108.67	2.07	3.98	P	31.78
225.3	5497.	0.540	0.15693×10^{-3}	0.070	0.726	108.67	1.81	4.03	P	29.05
230.4	5478.	0.579	0.14236×10^{-3}	0.070	0.726	108.67	1.69	4.04	P	27.73

233.0	5442.	0.638	0.11831×10^{-3}	0.068	0.724	108.67	1.54	4.06	P	41.61
224.6	5404.	0.683	0.95840×10^{-4}	0.067	0.723	108.67	1.44	4.07	P	51.03
198.3	5362.	0.721	0.72570×10^{-4}	0.065	0.721	108.67	1.37	4.09	P	75.68
143.7	5310.	0.751	0.47000×10^{-4}	0.064	0.719	108.67	1.31	4.11	P	94.22
227.5	3721.	0.132	0.48654×10^{-3}	0.078	0.734	108.67	6.92	3.96	P	17.34
223.6	3721.	0.333	0.40534×10^{-3}	0.078	0.734	108.67	2.89	3.96	P	18.84
216.1	3719.	0.487	0.32997×10^{-3}	0.078	0.734	108.67	2.00	3.97	P	19.67
203.6	3714.	0.601	0.26026×10^{-3}	0.077	0.733	108.67	1.63	3.97	P	22.42
178.2	3707.	0.699	0.17936×10^{-3}	0.077	0.733	108.67	1.41	3.98	P	29.76
155.8	3702.	0.738	0.13447×10^{-3}	0.076	0.733	108.67	1.33	3.98	P	31.75
249.8	3648.	0.826	0.20114×10^{-3}	0.073	0.730	108.67	1.19	4.01	P	36.54
263.3	3642.	0.873	0.17540×10^{-3}	0.073	0.729	108.67	1.13	4.02	P	35.83
303.3	3632.	0.940	0.13190×10^{-3}	0.072	0.729	108.67	1.05	4.02	P	63.91
409.4	3622.	0.986	0.91260×10^{-4}	0.071	0.728	108.67	1.00	4.03	P	119.02
222.7	2406.	0.126	0.45302×10^{-3}	0.078	0.734	108.67	7.21	3.96	P	21.84
216.7	2408.	0.312	0.37477×10^{-3}	0.078	0.734	108.67	3.08	3.96	P	25.55
206.1	2408.	0.453	0.30215×10^{-3}	0.078	0.734	108.67	2.15	3.97	P	27.86
190.0	2408.	0.557	0.23501×10^{-3}	0.078	0.734	108.67	1.76	3.97	P	31.85
159.1	2407.	0.644	0.15706×10^{-3}	0.078	0.734	108.67	1.52	3.97	P	46.19
132.8	2406.	0.678	0.11382×10^{-3}	0.077	0.734	108.67	1.45	3.97	P	48.45
241.5	2392.	0.751	0.18010×10^{-3}	0.076	0.733	108.67	1.31	3.99	P	63.69
253.5	2391.	0.794	0.15754×10^{-3}	0.076	0.732	108.67	1.24	3.99	P	52.74
286.5	2389.	0.854	0.11903×10^{-3}	0.076	0.732	108.67	1.15	3.99	P	96.64
358.6	2386.	0.894	0.83060×10^{-4}	0.075	0.732	108.67	1.10	4.00	P	153.02
934.3	2383.	0.921	0.45730×10^{-4}	0.075	0.732	108.67	1.07	4.00	P	866.55
187.4	6486.	0.071	0.27634×10^{-3}	0.081	0.736	108.67	11.82	3.94	P	17.75
190.5	6478.	0.186	0.23064×10^{-3}	0.081	0.736	108.67	5.02	3.94	P	19.60
190.1	6466.	0.274	0.18825×10^{-3}	0.080	0.735	108.67	3.48	3.95	P	20.72
184.6	6451.	0.340	0.14912×10^{-3}	0.079	0.735	108.67	2.83	3.95	P	23.63
166.8	6427.	0.398	0.10377×10^{-3}	0.078	0.734	108.67	2.43	3.96	P	30.83
148.0	6412.	0.422	0.78630×10^{-4}	0.078	0.734	108.67	2.30	3.96	P	32.99
238.1	6238.	0.489	0.14748×10^{-3}	0.072	0.728	108.67	2.00	4.02	P	28.98
241.6	6215.	0.526	0.13391×10^{-3}	0.071	0.727	108.67	1.86	4.03	P	27.50
239.4	6171.	0.581	0.11160×10^{-3}	0.070	0.726	108.67	1.69	4.04	P	40.39
223.1	6126.	0.625	0.90740×10^{-4}	0.068	0.724	108.67	1.57	4.06	P	48.00
187.5	6073.	0.661	0.69160×10^{-4}	0.066	0.722	108.67	1.49	4.08	P	69.95
127.6	6009.	0.691	0.45460×10^{-4}	0.064	0.720	108.67	1.43	4.10	P	81.22
218.8	4681.	0.113	0.40630×10^{-3}	0.079	0.734	108.67	7.93	3.95	P	16.93
218.2	4678.	0.282	0.33909×10^{-3}	0.078	0.734	108.67	3.40	3.96	P	18.45
213.5	4671.	0.411	0.27671×10^{-3}	0.078	0.734	108.67	2.36	3.97	P	19.17
203.5	4662.	0.507	0.21905×10^{-3}	0.077	0.733	108.67	1.92	3.97	P	22.07
180.1	4648.	0.591	0.15218×10^{-3}	0.076	0.733	108.67	1.66	3.98	P	28.67
158.2	4638.	0.624	0.11509×10^{-3}	0.076	0.732	108.67	1.57	3.98	P	30.59
239.1	4539.	0.706	0.18399×10^{-3}	0.071	0.728	108.67	1.39	4.03	P	30.70
248.8	4527.	0.750	0.16587×10^{-3}	0.071	0.727	108.67	1.31	4.03	P	29.90
268.7	4504.	0.817	0.13571×10^{-3}	0.070	0.726	108.67	1.21	4.04	P	47.30
292.6	4482.	0.867	0.10752×10^{-3}	0.069	0.725	108.67	1.14	4.06	P	64.76
328.0	4457.	0.907	0.78320×10^{-4}	0.067	0.724	108.67	1.09	4.07	P	114.13
405.8	4429.	0.938	0.46210×10^{-4}	0.066	0.722	108.67	1.05	4.08	P	260.52

205.1	6645.	0.011	0.18310×10^{-4}	0.078	0.733	108.67	42.37	3.96	C	193.50
152.6	6643.	0.021	0.28390×10^{-4}	0.078	0.733	108.67	29.87	3.96	C	78.40
133.8	6641.	0.034	0.37660×10^{-4}	0.078	0.733	108.67	21.59	3.96	C	46.38
121.1	6638.	0.053	0.48370×10^{-4}	0.078	0.733	108.67	15.24	3.96	C	30.04
115.9	6636.	0.066	0.54290×10^{-4}	0.078	0.733	108.67	12.76	3.96	C	25.36
171.8	6610.	0.107	0.11255×10^{-3}	0.077	0.732	108.67	8.33	3.97	C	20.39
188.2	6607.	0.139	0.13805×10^{-3}	0.076	0.732	108.67	6.60	3.97	C	21.96
205.1	6595.	0.208	0.18178×10^{-3}	0.076	0.731	108.67	4.53	3.98	C	16.90
211.7	6574.	0.291	0.22243×10^{-3}	0.075	0.731	108.67	3.30	3.98	C	20.41
213.0	6544.	0.394	0.26438×10^{-3}	0.074	0.730	108.67	2.47	4.00	C	17.36
209.7	6499.	0.528	0.31028×10^{-3}	0.072	0.728	108.67	1.85	4.01	C	18.36
285.6	4828.	0.005	0.11500×10^{-4}	0.078	0.733	108.67	55.54	3.96	C	780.60
155.1	4827.	0.014	0.27300×10^{-4}	0.078	0.733	108.67	37.20	3.96	C	143.29
136.1	4825.	0.029	0.41910×10^{-4}	0.078	0.733	108.67	24.11	3.96	C	68.73
127.2	4824.	0.048	0.55340×10^{-4}	0.078	0.733	108.67	16.56	3.96	C	43.04
120.4	4822.	0.076	0.70860×10^{-4}	0.078	0.733	108.67	11.27	3.96	C	29.14
117.4	4821.	0.095	0.79450×10^{-4}	0.078	0.733	108.67	9.30	3.96	C	24.88
194.0	4804.	0.159	0.17665×10^{-3}	0.077	0.732	108.67	5.85	3.97	C	24.54
207.1	4800.	0.207	0.20968×10^{-3}	0.077	0.732	108.67	4.55	3.98	C	21.77
220.6	4790.	0.311	0.26631×10^{-3}	0.076	0.731	108.67	3.09	3.98	C	17.77
226.8	4776.	0.429	0.31898×10^{-3}	0.076	0.731	108.67	2.26	3.99	C	19.30
228.6	4756.	0.574	0.37334×10^{-3}	0.075	0.730	108.67	1.71	4.00	C	19.07
226.9	4729.	0.759	0.43289×10^{-3}	0.074	0.729	108.67	1.30	4.02	C	20.35
524.5	3769.	0.006	0.13830×10^{-4}	0.078	0.733	108.67	53.40	3.96	C	1282.15
171.4	3769.	0.016	0.29840×10^{-4}	0.078	0.733	108.67	34.97	3.96	C	158.97
142.8	3768.	0.031	0.44630×10^{-4}	0.078	0.733	108.67	22.67	3.96	C	75.86
131.7	3768.	0.051	0.58250×10^{-4}	0.078	0.733	108.67	15.66	3.96	C	48.42
124.5	3768.	0.080	0.73980×10^{-4}	0.078	0.733	108.67	10.73	3.96	C	33.35
121.8	3768.	0.100	0.82690×10^{-4}	0.078	0.733	108.67	8.90	3.96	C	28.77
183.5	3762.	0.160	0.16333×10^{-3}	0.077	0.733	108.67	5.80	3.97	C	26.84
198.3	3762.	0.205	0.19448×10^{-3}	0.077	0.733	108.67	4.61	3.97	C	25.66
216.0	3759.	0.300	0.24790×10^{-3}	0.077	0.732	108.67	3.20	3.97	C	20.67
225.6	3754.	0.409	0.29767×10^{-3}	0.076	0.732	108.67	2.37	3.98	C	23.09
230.9	3746.	0.544	0.34916×10^{-3}	0.076	0.732	108.67	1.80	3.99	C	22.09
232.9	3735.	0.718	0.40569×10^{-3}	0.075	0.731	108.67	1.37	3.99	C	23.77
133.3	2220.	0.008	0.18280×10^{-4}	0.077	0.732	108.67	49.24	3.96	C	310.41
123.3	2220.	0.019	0.33630×10^{-4}	0.077	0.732	108.67	31.21	3.96	C	133.43
120.2	2220.	0.036	0.47820×10^{-4}	0.077	0.732	108.67	20.37	3.96	C	79.74
121.9	2221.	0.057	0.60890×10^{-4}	0.077	0.733	108.67	14.31	3.97	C	60.21
121.3	2221.	0.088	0.76000×10^{-4}	0.077	0.733	108.67	9.98	3.97	C	45.40
121.2	2221.	0.107	0.84360×10^{-4}	0.077	0.733	108.67	8.35	3.97	C	41.25
158.6	2219.	0.163	0.13962×10^{-3}	0.077	0.732	108.67	5.70	3.97	C	59.12
165.5	2219.	0.200	0.15815×10^{-3}	0.077	0.732	108.67	4.70	3.97	C	38.79
174.7	2219.	0.275	0.18992×10^{-3}	0.077	0.732	108.67	3.48	3.98	C	32.71
180.3	2218.	0.357	0.21956×10^{-3}	0.077	0.732	108.67	2.71	3.98	C	33.81
184.1	2217.	0.454	0.25025×10^{-3}	0.076	0.732	108.67	2.14	3.98	C	37.01
186.8	2215.	0.577	0.28402×10^{-3}	0.076	0.732	108.67	1.70	3.98	C	41.48
208.5	5764.	0.092	0.33095×10^{-3}	0.079	0.735	108.67	9.50	3.95	P	18.10
210.9	5759.	0.230	0.27629×10^{-3}	0.079	0.735	108.67	4.12	3.96	P	19.63

209.2	5748.	0.335	0.22556×10^{-3}	0.078	0.734	108.67	2.87	3.96	P	20.54
201.7	5735.	0.414	0.17871×10^{-3}	0.078	0.734	108.67	2.34	3.96	P	23.40
181.2	5713.	0.483	0.12441×10^{-3}	0.077	0.733	108.67	2.02	3.98	P	30.45
160.4	5699.	0.511	0.94290×10^{-4}	0.076	0.732	108.67	1.91	3.98	P	32.61
253.4	5550.	0.587	0.17074×10^{-3}	0.071	0.727	108.67	1.67	4.03	P	29.10
261.3	5530.	0.629	0.15574×10^{-3}	0.070	0.726	108.67	1.56	4.04	P	28.60
270.5	5493.	0.693	0.13107×10^{-3}	0.069	0.725	108.67	1.42	4.06	P	42.38
268.6	5455.	0.743	0.10800×10^{-3}	0.067	0.723	108.67	1.33	4.07	P	53.19
248.1	5410.	0.786	0.84120×10^{-4}	0.065	0.721	108.67	1.26	4.09	P	74.99
195.6	5356.	0.822	0.57880×10^{-4}	0.063	0.719	108.67	1.20	4.11	P	98.02
155.9	6550.	0.040	0.13292×10^{-3}	0.077	0.732	108.67	19.04	3.97	P	23.63
155.9	6546.	0.095	0.11174×10^{-3}	0.077	0.732	108.67	9.26	3.97	P	28.63
152.8	6539.	0.138	0.92120×10^{-4}	0.076	0.732	108.67	6.63	3.98	P	31.28
145.7	6530.	0.171	0.74010×10^{-4}	0.076	0.731	108.67	5.45	3.98	P	33.73
129.3	6518.	0.200	0.53050×10^{-4}	0.076	0.731	108.67	4.70	3.98	P	49.78
114.6	6509.	0.212	0.41420×10^{-4}	0.075	0.731	108.67	4.45	3.99	P	51.30
227.8	6412.	0.254	0.92770×10^{-4}	0.072	0.728	108.67	3.77	4.01	P	47.36
223.3	6398.	0.277	0.83310×10^{-4}	0.072	0.727	108.67	3.47	4.02	P	33.52
205.5	6371.	0.311	0.67410×10^{-4}	0.071	0.726	108.67	3.10	4.03	P	55.50
175.4	6341.	0.337	0.52570×10^{-4}	0.070	0.725	108.67	2.87	4.04	P	55.70
131.0	6306.	0.358	0.37190×10^{-4}	0.069	0.724	108.67	2.71	4.05	P	110.70
71.6	6262.	0.375	0.20280×10^{-4}	0.067	0.723	108.67	2.59	4.07	P	114.29
1050.1	4976.	0.007	0.16710×10^{-4}	0.080	0.735	108.67	49.89	3.94	C	1634.71
228.8	4975.	0.018	0.29910×10^{-4}	0.080	0.735	108.67	32.63	3.94	C	162.58
175.9	4975.	0.033	0.42110×10^{-4}	0.080	0.735	108.67	21.88	3.94	C	75.70
154.2	4975.	0.051	0.53340×10^{-4}	0.080	0.735	108.67	15.61	3.94	C	47.95
139.9	4974.	0.078	0.66310×10^{-4}	0.080	0.735	108.67	11.03	3.95	C	32.10
134.2	4974.	0.095	0.73490×10^{-4}	0.080	0.735	108.67	9.27	3.95	C	27.88
215.8	4960.	0.152	0.16023×10^{-3}	0.079	0.735	108.67	6.07	3.95	C	24.02
235.4	4959.	0.196	0.19437×10^{-3}	0.079	0.734	108.67	4.78	3.95	C	23.72
257.6	4952.	0.293	0.25291×10^{-3}	0.079	0.734	108.67	3.27	3.96	C	19.03
268.5	4942.	0.405	0.30744×10^{-3}	0.078	0.734	108.67	2.39	3.97	C	21.32
272.9	4928.	0.546	0.36381×10^{-3}	0.077	0.733	108.67	1.79	3.97	C	19.94
273.0	4906.	0.728	0.42565×10^{-3}	0.076	0.732	108.67	1.35	3.98	C	20.86
521.3	5225.	0.005	0.11330×10^{-4}	0.085	0.739	108.67	53.14	3.91	C	1138.06
196.6	5224.	0.013	0.25910×10^{-4}	0.085	0.739	108.67	36.65	3.91	C	151.28
165.3	5223.	0.027	0.39390×10^{-4}	0.085	0.739	108.67	24.42	3.91	C	72.52
152.2	5223.	0.045	0.51790×10^{-4}	0.085	0.739	108.67	17.10	3.91	C	46.22
142.8	5222.	0.071	0.66120×10^{-4}	0.084	0.739	108.67	11.81	3.91	C	31.36
138.9	5222.	0.088	0.74060×10^{-4}	0.084	0.739	108.67	9.81	3.91	C	27.33
216.8	5207.	0.144	0.15612×10^{-3}	0.084	0.739	108.67	6.34	3.91	C	21.26
241.2	5206.	0.188	0.19226×10^{-3}	0.084	0.739	108.67	4.97	3.92	C	22.76
269.2	5201.	0.284	0.25426×10^{-3}	0.083	0.739	108.67	3.36	3.92	C	18.75
284.2	5191.	0.398	0.31201×10^{-3}	0.083	0.738	108.67	2.43	3.93	C	22.00
291.9	5176.	0.541	0.37173×10^{-3}	0.082	0.738	108.67	1.80	3.94	C	19.39
294.2	5155.	0.727	0.43728×10^{-3}	0.081	0.737	108.67	1.35	3.95	C	20.57
223.5	5058.	0.013	0.25600×10^{-4}	0.090	0.744	108.67	36.46	3.87	C	177.57
179.1	5058.	0.026	0.40150×10^{-4}	0.090	0.744	108.67	24.29	3.87	C	79.41
163.5	5057.	0.044	0.53540×10^{-4}	0.090	0.744	108.67	16.90	3.87	C	49.35

153.1	5057.	0.072	0.69020×10^{-4}	0.090	0.744	108.67	11.58	3.87	C	33.29
149.1	5057.	0.090	0.77590×10^{-4}	0.090	0.744	108.67	9.58	3.87	C	28.97
236.6	5047.	0.148	0.16499×10^{-3}	0.089	0.744	108.67	6.13	3.88	C	23.37
260.7	5047.	0.194	0.20163×10^{-3}	0.089	0.744	108.67	4.79	3.88	C	23.76
288.9	5043.	0.294	0.26447×10^{-3}	0.089	0.743	108.67	3.24	3.88	C	19.76
304.5	5035.	0.412	0.32304×10^{-3}	0.088	0.743	108.67	2.34	3.88	C	22.31
313.5	5025.	0.560	0.38365×10^{-3}	0.087	0.743	108.67	1.74	3.90	C	20.48
317.0	5009.	0.751	0.45024×10^{-3}	0.086	0.742	108.67	1.31	3.91	C	21.73
363.4	4820.	0.000	0.14840×10^{-4}	0.078	0.735	108.67	76.17	3.94	C	576.46
158.0	4765.	0.090	0.83810×10^{-4}	0.077	0.733	108.67	9.71	3.96	C	27.92
159.8	4764.	0.112	0.93810×10^{-4}	0.077	0.733	108.67	8.01	3.97	C	30.57
197.5	4743.	0.174	0.15244×10^{-3}	0.076	0.732	108.67	5.35	3.97	C	29.99
213.4	4740.	0.216	0.18005×10^{-3}	0.076	0.732	108.67	4.37	3.98	C	21.54
231.5	4730.	0.304	0.22747×10^{-3}	0.076	0.731	108.67	3.16	3.98	C	17.92
240.2	4718.	0.405	0.27162×10^{-3}	0.075	0.731	108.67	2.39	3.99	C	17.56
243.6	4701.	0.529	0.31727×10^{-3}	0.074	0.730	108.67	1.85	4.00	C	18.26
242.4	4678.	0.687	0.36735×10^{-3}	0.073	0.729	108.67	1.43	4.01	C	19.33

APPENDIX B1

Convective boiling of R1234yf within a micro-fin tube
(file: hqgwp3b.dat)

q'' (Wm^{-2})	ΔT_s (K)	x_q	G_r ($kg\ m^{-2}s^{-1}$)	T_w (K)	T_s (K)	T_f (K)	z (m)	M_w (g/mole)	flow
3208.	1.07	0.19	218.	279.14	278.10	280.71	0.35	86.28	C
3910.	1.44	0.23	218.	279.64	278.27	281.01	0.97	86.28	C
4558.	1.73	0.27	218.	280.10	278.47	281.39	1.54	86.28	C
5155.	1.96	0.31	218.	280.52	278.68	281.93	2.06	86.28	C
5845.	2.18	0.36	218.	281.01	278.96	282.49	2.66	86.28	C
6227.	2.28	0.40	218.	281.28	279.14	283.05	3.00	86.28	C
9486.	2.46	0.49	218.	281.84	279.50	283.45	3.69	86.28	C
9616.	2.47	0.54	218.	282.11	279.79	284.34	4.03	86.28	C
9838.	2.47	0.64	218.	282.58	280.32	285.47	4.61	86.28	C
10045.	2.43	0.73	218.	283.02	280.82	286.40	5.15	86.28	C
10260.	2.37	0.84	218.	283.48	281.34	287.57	5.72	86.28	C
10496.	2.27	0.95	218.	283.98	281.92	288.55	6.34	86.28	C
3368.	1.23	0.19	216.	279.41	278.18	280.94	0.35	86.28	C
4127.	1.56	0.23	216.	279.89	278.37	281.23	0.97	86.28	C
4828.	1.82	0.27	216.	280.33	278.57	281.60	1.54	86.28	C
5474.	2.02	0.32	216.	280.74	278.80	282.12	2.06	86.28	C
6220.	2.21	0.38	216.	281.22	279.11	282.65	2.66	86.28	C
6632.	2.29	0.41	216.	281.48	279.31	283.19	3.00	86.28	C
9419.	2.44	0.51	216.	282.01	279.66	283.55	3.69	86.28	C
9508.	2.45	0.56	216.	282.28	279.96	284.36	4.03	86.28	C
9661.	2.43	0.66	216.	282.74	280.48	285.35	4.61	86.28	C
9803.	2.39	0.76	216.	283.16	280.98	286.18	5.15	86.28	C
9951.	2.32	0.86	216.	283.60	281.49	287.19	5.72	86.28	C
10114.	2.21	0.97	216.	284.09	282.06	288.04	6.34	86.28	C
2152.	1.18	0.11	297.	279.45	278.26	280.66	0.35	86.28	C
2959.	1.45	0.13	297.	279.80	278.33	280.84	0.97	86.28	C
3706.	1.68	0.15	297.	280.12	278.42	281.16	1.54	86.28	C
4392.	1.86	0.18	297.	280.42	278.53	281.62	2.06	86.28	C
5186.	2.04	0.21	297.	280.76	278.69	282.04	2.66	86.28	C
5625.	2.13	0.23	297.	280.95	278.79	282.51	3.00	86.28	C
9536.	2.32	0.30	297.	281.34	278.94	282.84	3.69	86.28	C
9452.	2.35	0.34	297.	281.53	279.13	283.58	4.03	86.28	C
9309.	2.40	0.40	297.	281.87	279.43	284.69	4.61	86.28	C
9176.	2.44	0.46	297.	282.17	279.68	285.64	5.15	86.28	C
9038.	2.48	0.53	297.	282.49	279.93	286.80	5.72	86.28	C
8886.	2.52	0.60	297.	282.85	280.17	287.53	6.34	86.28	C

2690.	1.65	0.12	164.	280.03	278.27	281.45	0.35	86.28	C
3357.	1.89	0.16	164.	280.48	278.46	281.67	0.97	86.28	C
3974.	2.06	0.20	164.	280.90	278.68	282.02	1.54	86.28	C
4541.	2.18	0.25	164.	281.28	278.93	282.53	2.06	86.28	C
5197.	2.28	0.31	164.	281.72	279.27	282.98	2.66	86.28	C
5560.	2.32	0.35	164.	281.97	279.48	283.43	3.00	86.28	C
7425.	2.36	0.46	164.	282.47	279.93	283.72	3.69	86.28	C
7288.	2.33	0.51	164.	282.72	280.24	284.44	4.03	86.28	C
7052.	2.26	0.61	164.	283.15	280.77	285.17	4.61	86.28	C
6832.	2.19	0.69	164.	283.55	281.25	285.78	5.15	86.28	C
6604.	2.11	0.78	164.	283.96	281.73	286.51	5.72	86.28	C
6353.	2.01	0.88	164.	284.42	282.24	287.07	6.34	86.28	C
2461.	2.12	0.09	101.	280.42	278.09	281.45	0.35	86.28	C
2604.	2.13	0.14	101.	280.75	278.35	281.66	0.97	86.28	C
2736.	2.13	0.20	101.	281.05	278.61	281.94	1.54	86.28	C
2857.	2.12	0.25	101.	281.33	278.87	282.29	2.06	86.28	C
2997.	2.09	0.31	101.	281.65	279.20	282.57	2.66	86.28	C
3075.	2.06	0.35	101.	281.83	279.40	282.82	3.00	86.28	C
3174.	2.03	0.42	101.	282.20	279.77	282.92	3.69	86.28	C
3188.	1.99	0.46	101.	282.38	279.99	283.33	4.03	86.28	C
3212.	1.91	0.53	101.	282.69	280.38	283.61	4.61	86.28	C
3234.	1.84	0.60	101.	282.98	280.74	283.91	5.15	86.28	C
3257.	1.76	0.66	101.	283.28	281.13	284.24	5.72	86.28	C
3283.	1.66	0.74	101.	283.62	281.56	284.53	6.34	86.28	C
20662.	5.06	0.16	213.	284.03	278.63	289.36	0.35	86.28	P
16754.	4.06	0.35	213.	283.87	279.62	287.64	0.97	86.28	P
13136.	3.24	0.49	213.	283.72	280.41	286.47	1.54	86.28	P
9801.	2.59	0.60	213.	283.59	280.99	285.56	2.06	86.28	P
5940.	1.98	0.68	213.	283.43	281.44	284.91	2.66	86.28	P
3801.	1.72	0.71	213.	283.34	281.59	284.49	3.00	86.28	P
5843.	1.41	0.77	213.	283.16	281.50	284.15	3.69	86.28	P
5018.	1.17	0.80	213.	283.07	281.64	283.88	4.03	86.28	P
3604.	0.84	0.85	213.	282.92	281.83	283.42	4.61	86.28	P
2284.	0.60	0.88	213.	282.77	281.91	283.26	5.15	86.28	P
915.	0.43	0.90	213.	282.63	281.91	283.08	5.72	86.28	P
19644.	4.22	0.18	296.	282.87	278.51	287.84	0.35	86.28	P
16139.	3.46	0.32	296.	282.61	279.16	286.25	0.97	86.28	P
12892.	2.84	0.42	296.	282.38	279.67	285.13	1.54	86.28	P
9900.	2.33	0.49	296.	282.16	280.03	284.22	2.06	86.28	P
6436.	1.84	0.55	296.	281.91	280.30	283.56	2.66	86.28	P
4517.	1.62	0.58	296.	281.78	280.38	283.10	3.00	86.28	P
7183.	1.42	0.63	296.	281.49	280.07	282.70	3.69	86.28	P
6284.	1.21	0.66	296.	281.35	280.16	282.37	4.03	86.28	P
4741.	0.90	0.70	296.	281.11	280.26	281.79	4.61	86.28	P
3301.	0.66	0.73	296.	280.89	280.29	281.57	5.15	86.28	P

1807.	0.47	0.75	296.	280.66	280.24	281.31	5.72	86.28	P
162.	0.33	0.76	296.	280.40	280.10	281.28	6.34	86.28	P
16982.	4.44	0.21	162.	283.51	278.76	287.91	0.35	86.28	P
13648.	3.44	0.42	162.	283.42	279.88	286.50	0.97	86.28	P
10561.	2.63	0.57	162.	283.34	280.78	285.57	1.54	86.28	P
7716.	2.00	0.68	162.	283.27	281.43	284.87	2.06	86.28	P
4423.	1.43	0.77	162.	283.18	281.92	284.37	2.66	86.28	P
2599.	1.20	0.80	162.	283.14	282.07	284.06	3.00	86.28	P
4294.	0.88	0.85	162.	283.04	282.13	283.80	3.69	86.28	P
3634.	0.67	0.88	162.	282.99	282.30	283.64	4.03	86.28	P
2501.	0.38	0.93	162.	282.91	282.50	283.30	4.61	86.28	P
1444.	0.19	0.95	162.	282.84	282.60	283.21	5.15	86.28	P
348.	0.07	0.97	162.	282.76	282.61	283.09	5.72	86.28	P
10586.	3.87	0.22	92.	283.00	278.83	285.75	0.35	86.28	P
8353.	2.86	0.44	92.	282.98	280.07	284.84	0.97	86.28	P
6286.	2.05	0.61	92.	282.96	281.06	284.30	1.54	86.28	P
4381.	1.44	0.72	92.	282.94	281.75	283.95	2.06	86.28	P
2177.	0.92	0.81	92.	282.92	282.25	283.68	2.66	86.28	P
956.	0.73	0.83	92.	282.91	282.38	283.51	3.00	86.28	P
2443.	0.41	0.87	92.	282.89	282.55	283.35	3.69	86.28	P
1981.	0.22	0.91	92.	282.88	282.74	283.31	4.03	86.28	P
1188.	0.00	0.94	92.	282.86	282.96	283.09	4.61	86.28	P
2834.	1.85	0.02	214.	280.02	278.03	281.42	0.35	86.28	C
3541.	2.11	0.05	214.	280.47	278.16	281.65	0.97	86.28	C
4195.	2.31	0.09	214.	280.88	278.32	282.00	1.54	86.28	C
4797.	2.47	0.13	214.	281.26	278.50	282.53	2.06	86.28	C
5492.	2.63	0.18	214.	281.71	278.74	283.00	2.66	86.28	C
5877.	2.69	0.21	214.	281.95	278.90	283.47	3.00	86.28	C
8570.	2.84	0.29	214.	282.45	279.18	283.85	3.69	86.28	C
8683.	2.85	0.34	214.	282.70	279.43	284.59	4.03	86.28	C
8875.	2.85	0.43	214.	283.13	279.86	285.50	4.61	86.28	C
9055.	2.83	0.51	214.	283.52	280.28	286.26	5.15	86.28	C
9241.	2.79	0.60	214.	283.94	280.72	287.16	5.72	86.28	C
9446.	2.72	0.71	214.	284.39	281.22	287.99	6.34	86.28	C
2289.	1.15	0.09	302.	279.38	278.19	280.69	0.35	86.28	C
3121.	1.45	0.11	302.	279.76	278.27	280.87	0.97	86.28	C
3889.	1.70	0.13	302.	280.12	278.36	281.18	1.54	86.28	C
4596.	1.91	0.16	302.	280.44	278.47	281.65	2.06	86.28	C
5414.	2.12	0.19	302.	280.82	278.63	282.09	2.66	86.28	C
5866.	2.23	0.21	302.	281.03	278.73	282.54	3.00	86.28	C
8955.	2.48	0.28	302.	281.47	278.85	282.86	3.69	86.28	C
9270.	2.54	0.31	302.	281.68	279.01	283.63	4.03	86.28	C
9809.	2.63	0.38	302.	282.04	279.31	284.62	4.61	86.28	C
10311.	2.71	0.45	302.	282.39	279.59	285.47	5.15	86.28	C
10832.	2.76	0.52	302.	282.74	279.89	286.53	5.72	86.28	C

11404.	2.81	0.61	302.	283.13	280.22	287.48	6.34	86.28	C
2296.	1.19	0.08	303.	279.38	278.15	280.70	0.35	86.28	C
3122.	1.49	0.10	303.	279.77	278.22	280.87	0.97	86.28	C
3886.	1.73	0.12	303.	280.12	278.32	281.19	1.54	86.28	C
4589.	1.94	0.15	303.	280.45	278.43	281.66	2.06	86.28	C
5402.	2.15	0.18	303.	280.83	278.58	282.09	2.66	86.28	C
5851.	2.26	0.20	303.	281.04	278.68	282.54	3.00	86.28	C
8949.	2.51	0.27	303.	281.46	278.79	282.86	3.69	86.28	C
9264.	2.57	0.30	303.	281.68	278.96	283.63	4.03	86.28	C
9804.	2.66	0.37	303.	282.04	279.25	284.62	4.61	86.28	C
10308.	2.73	0.43	303.	282.38	279.52	285.47	5.15	86.28	C
10830.	2.79	0.51	303.	282.73	279.82	286.53	5.72	86.28	C
11404.	2.84	0.59	303.	283.12	280.15	287.47	6.34	86.28	C
2616.	1.82	0.05	164.	280.07	278.10	281.42	0.35	86.28	C
3146.	2.03	0.09	164.	280.51	278.27	281.66	0.97	86.28	C
3637.	2.20	0.13	164.	280.92	278.47	282.01	1.54	86.28	C
4088.	2.33	0.18	164.	281.30	278.68	282.52	2.06	86.28	C
4610.	2.44	0.23	164.	281.74	278.98	282.95	2.66	86.28	C
4899.	2.48	0.27	164.	281.98	279.16	283.38	3.00	86.28	C
6832.	2.55	0.36	164.	282.47	279.53	283.73	3.69	86.28	C
6861.	2.54	0.41	164.	282.72	279.81	284.40	4.03	86.28	C
6912.	2.50	0.50	164.	283.14	280.29	285.16	4.61	86.28	C
6960.	2.44	0.58	164.	283.53	280.75	285.81	5.15	86.28	C
7009.	2.36	0.67	164.	283.94	281.24	286.59	5.72	86.28	C
7063.	2.26	0.78	164.	284.39	281.78	287.28	6.34	86.28	C
2759.	1.94	0.07	158.	280.26	278.15	281.57	0.35	86.28	C
3289.	2.11	0.11	158.	280.68	278.34	281.79	0.97	86.28	C
3780.	2.24	0.15	158.	281.07	278.56	282.13	1.54	86.28	C
4231.	2.34	0.20	158.	281.42	278.79	282.61	2.06	86.28	C
4753.	2.41	0.26	158.	281.84	279.11	283.01	2.66	86.28	C
5042.	2.43	0.30	158.	282.07	279.31	283.41	3.00	86.28	C
6542.	2.48	0.39	158.	282.54	279.69	283.71	3.69	86.28	C
6550.	2.45	0.44	158.	282.77	279.97	284.31	4.03	86.28	C
6563.	2.39	0.53	158.	283.17	280.45	284.93	4.61	86.28	C
6575.	2.33	0.62	158.	283.54	280.91	285.48	5.15	86.28	C
6588.	2.24	0.71	158.	283.93	281.39	286.12	5.72	86.28	C
6601.	2.13	0.81	158.	284.35	281.93	286.70	6.34	86.28	C
2511.	2.11	0.09	97.	280.64	278.26	281.71	0.35	86.28	C
2704.	2.11	0.14	97.	280.99	278.54	281.90	0.97	86.28	C
2882.	2.10	0.20	97.	281.32	278.83	282.21	1.54	86.28	C
3045.	2.07	0.26	97.	281.62	279.13	282.61	2.06	86.28	C
3234.	2.02	0.33	97.	281.96	279.50	282.91	2.66	86.28	C
3339.	1.99	0.37	97.	282.15	279.73	283.17	3.00	86.28	C
3044.	1.95	0.45	97.	282.55	280.14	283.27	3.69	86.28	C
3047.	1.91	0.49	97.	282.74	280.36	283.63	4.03	86.28	C

3051.	1.86	0.56	97.	283.07	280.75	283.90	4.61	86.28	C
3056.	1.80	0.62	97.	283.39	281.12	284.19	5.15	86.28	C
3061.	1.75	0.69	97.	283.71	281.51	284.47	5.72	86.28	C
3066.	1.68	0.77	97.	284.06	281.93	284.74	6.34	86.28	C
20940.	4.96	0.17	216.	283.93	278.66	289.20	0.35	86.28	P
17035.	3.97	0.37	216.	283.77	279.65	287.53	0.97	86.28	P
13419.	3.15	0.51	216.	283.61	280.46	286.38	1.54	86.28	P
10087.	2.50	0.62	216.	283.47	281.04	285.45	2.06	86.28	P
6229.	1.90	0.71	216.	283.31	281.50	284.81	2.66	86.28	P
4091.	1.64	0.74	216.	283.22	281.64	284.38	3.00	86.28	P
6110.	1.31	0.80	216.	283.03	281.58	284.04	3.69	86.28	P
5263.	1.08	0.83	216.	282.94	281.73	283.77	4.03	86.28	P
3809.	0.74	0.88	216.	282.78	281.93	283.30	4.61	86.28	P
2452.	0.50	0.91	216.	282.64	282.02	283.14	5.15	86.28	P
1045.	0.33	0.93	216.	282.48	282.02	282.96	5.72	86.28	P
18997.	4.32	0.15	301.	282.86	278.38	287.68	0.35	86.28	P
15678.	3.58	0.28	301.	282.60	278.99	286.15	0.97	86.28	P
12604.	2.97	0.37	301.	282.36	279.46	285.08	1.54	86.28	P
9771.	2.46	0.45	301.	282.14	279.79	284.17	2.06	86.28	P
6492.	1.98	0.51	301.	281.88	280.05	283.52	2.66	86.28	P
4675.	1.75	0.53	301.	281.74	280.13	283.06	3.00	86.28	P
7347.	1.54	0.58	301.	281.45	279.82	282.65	3.69	86.28	P
6429.	1.33	0.61	301.	281.30	279.91	282.33	4.03	86.28	P
4854.	1.01	0.65	301.	281.06	280.01	281.73	4.61	86.28	P
3383.	0.77	0.68	301.	280.83	280.04	281.51	5.15	86.28	P
1858.	0.57	0.70	301.	280.59	279.99	281.25	5.72	86.28	P
178.	0.43	0.71	301.	280.33	279.85	281.22	6.34	86.28	P
15912.	4.43	0.15	169.	283.34	278.57	287.50	0.35	86.28	P
12814.	3.52	0.34	169.	283.24	279.53	286.17	0.97	86.28	P
9946.	2.77	0.48	169.	283.16	280.31	285.29	1.54	86.28	P
7303.	2.19	0.58	169.	283.08	280.87	284.62	2.06	86.28	P
4243.	1.66	0.66	169.	282.99	281.30	284.16	2.66	86.28	P
2548.	1.43	0.68	169.	282.94	281.43	283.85	3.00	86.28	P
4272.	1.13	0.73	169.	282.83	281.44	283.60	3.69	86.28	P
3617.	0.93	0.76	169.	282.78	281.60	283.44	4.03	86.28	P
2494.	0.65	0.80	169.	282.70	281.80	283.08	4.61	86.28	P
1445.	0.46	0.83	169.	282.61	281.89	282.99	5.15	86.28	P
357.	0.35	0.84	169.	282.53	281.89	282.87	5.72	86.28	P
10003.	3.81	0.20	91.	282.82	278.71	285.42	0.35	86.28	P
7901.	2.84	0.42	91.	282.80	279.89	284.57	0.97	86.28	P
5955.	2.06	0.58	91.	282.79	280.83	284.05	1.54	86.28	P
4162.	1.47	0.69	91.	282.77	281.49	283.73	2.06	86.28	P
2087.	0.96	0.77	91.	282.75	281.98	283.48	2.66	86.28	P
938.	0.77	0.79	91.	282.74	282.11	283.32	3.00	86.28	P
2345.	0.46	0.83	91.	282.72	282.27	283.17	3.69	86.28	P

1893.	0.28	0.86	91.	282.71	282.46	283.14	4.03	86.28	P
1118.	0.05	0.90	91.	282.70	282.67	282.93	4.61	86.28	P
395.	-.08	0.92	91.	282.68	282.75	282.91	5.15	86.28	P

APPENDIX B2

Convective boiling of R134a within a micro-fin tube
(file: hfqgwp3b.dat)

q'' (Wm^{-2})	ΔT_s (K)	x_q	G_r (kg m^{-2}s^{-1})	T_w (K)	T_s (K)	T_f (K)	z (m)	M_w (g/mole)	flow
1077.	1.34	0.08	231.	279.50	278.14	280.96	0.35	87.21	C
2185.	1.67	0.10	231.	279.91	278.21	281.02	0.97	87.21	C
3209.	1.93	0.12	231.	280.29	278.33	281.33	1.54	87.21	C
4152.	2.13	0.15	231.	280.64	278.48	281.85	2.06	87.21	C
5241.	2.31	0.20	231.	281.04	278.71	282.33	2.66	87.21	C
5844.	2.39	0.23	231.	281.26	278.86	282.82	3.00	87.21	C
8808.	2.54	0.31	231.	281.72	279.15	283.21	3.69	87.21	C
9171.	2.55	0.36	231.	281.95	279.39	284.04	4.03	87.21	C
9792.	2.56	0.45	231.	282.34	279.81	285.20	4.61	87.21	C
10370.	2.53	0.54	231.	282.70	280.21	286.15	5.15	87.21	C
10970.	2.48	0.63	231.	283.08	280.65	287.36	5.72	87.21	C
11630.	2.39	0.75	231.	283.49	281.15	288.47	6.34	87.21	C
2283.	0.90	0.08	298.	279.03	278.13	280.33	0.35	87.21	C
3031.	1.22	0.11	298.	279.42	278.22	280.53	0.97	87.21	C
3722.	1.49	0.13	298.	279.79	278.32	280.85	1.54	87.21	C
4358.	1.72	0.15	298.	280.12	278.44	281.35	2.06	87.21	C
5094.	1.96	0.19	298.	280.51	278.60	281.83	2.66	87.21	C
5500.	2.07	0.21	298.	280.73	278.70	282.32	3.00	87.21	C
8757.	2.34	0.27	298.	281.17	278.84	282.70	3.69	87.21	C
9168.	2.41	0.31	298.	281.39	279.02	283.51	4.03	87.21	C
9872.	2.52	0.38	298.	281.76	279.31	284.66	4.61	87.21	C
10528.	2.62	0.45	298.	282.11	279.58	285.64	5.15	87.21	C
11208.	2.70	0.53	298.	282.47	279.86	286.89	5.72	87.21	C
11955.	2.78	0.62	298.	282.87	280.17	288.02	6.34	87.21	C
2425.	1.67	0.02	162.	280.01	278.27	281.34	0.35	87.21	C
2934.	1.88	0.05	162.	280.46	278.45	281.56	0.97	87.21	C
3404.	2.05	0.09	162.	280.87	278.66	281.89	1.54	87.21	C
3837.	2.18	0.14	162.	281.24	278.88	282.40	2.06	87.21	C
4338.	2.29	0.19	162.	281.68	279.17	282.86	2.66	87.21	C
4615.	2.34	0.23	162.	281.92	279.36	283.27	3.00	87.21	C
6516.	2.43	0.31	162.	282.42	279.73	283.57	3.69	87.21	C
6591.	2.43	0.37	162.	282.67	279.99	284.24	4.03	87.21	C
6718.	2.43	0.45	162.	283.09	280.43	285.05	4.61	87.21	C
6838.	2.41	0.54	162.	283.48	280.84	285.73	5.15	87.21	C
6961.	2.39	0.63	162.	283.89	281.27	286.54	5.72	87.21	C
7097.	2.34	0.73	162.	284.34	281.74	287.25	6.34	87.21	C
965.	1.63	0.01	104.	279.77	278.02	280.97	0.35	87.21	C
1482.	1.78	0.04	104.	280.14	278.15	281.06	0.97	87.21	C

1960.	1.88	0.07	104.	280.48	278.33	281.34	1.54	87.21	C
2400.	1.94	0.11	104.	280.79	278.53	281.78	2.06	87.21	C
2908.	1.99	0.17	104.	281.16	278.83	282.15	2.66	87.21	C
3190.	1.99	0.20	104.	281.36	279.02	282.51	3.00	87.21	C
3989.	1.97	0.29	104.	281.78	279.46	282.73	3.69	87.21	C
4004.	1.93	0.34	104.	281.98	279.72	283.29	4.03	87.21	C
4030.	1.86	0.42	104.	282.33	280.17	283.90	4.61	87.21	C
4054.	1.79	0.50	104.	282.66	280.58	284.44	5.15	87.21	C
4079.	1.72	0.58	104.	283.00	281.01	285.10	5.72	87.21	C
4107.	1.63	0.68	104.	283.38	281.48	285.62	6.34	87.21	C
24022.	5.28	0.14	223.	284.17	278.73	292.39	0.35	87.21	P
19258.	4.12	0.36	223.	283.87	279.85	289.33	0.97	87.21	P
14844.	3.19	0.52	223.	283.60	280.67	287.46	1.54	87.21	P
10774.	2.47	0.64	223.	283.34	281.22	285.95	2.06	87.21	P
6061.	1.79	0.72	223.	283.05	281.62	284.93	2.66	87.21	P
3449.	1.49	0.75	223.	282.89	281.72	284.26	3.00	87.21	P
5579.	1.12	0.80	223.	282.55	281.54	283.77	3.69	87.21	P
4818.	0.85	0.83	223.	282.39	281.64	283.35	4.03	87.21	P
3513.	0.45	0.87	223.	282.11	281.77	282.71	4.61	87.21	P
2294.	0.14	0.90	223.	281.84	281.81	282.47	5.15	87.21	P
1030.	-.11	0.91	223.	281.57	281.78	282.21	5.72	87.21	P
24095.	5.28	0.14	224.	284.18	278.76	292.36	0.35	87.21	P
19321.	4.12	0.36	224.	283.88	279.87	289.32	0.97	87.21	P
14897.	3.20	0.52	224.	283.60	280.69	287.45	1.54	87.21	P
10818.	2.47	0.63	224.	283.35	281.25	285.94	2.06	87.21	P
6095.	1.79	0.72	224.	283.06	281.65	284.94	2.66	87.21	P
3477.	1.49	0.75	224.	282.89	281.75	284.27	3.00	87.21	P
5598.	1.11	0.79	224.	282.56	281.56	283.78	3.69	87.21	P
4843.	0.84	0.82	224.	282.39	281.67	283.35	4.03	87.21	P
3549.	0.44	0.87	224.	282.11	281.79	282.71	4.61	87.21	P
2341.	0.13	0.89	224.	281.84	281.83	282.47	5.15	87.21	P
1087.	0.00	0.91	224.	281.57	281.81	282.21	5.72	87.21	P
22606.	4.97	0.10	296.	283.64	278.57	291.41	0.35	87.21	P
18269.	4.00	0.26	296.	283.26	279.33	288.49	0.97	87.21	P
14250.	3.22	0.37	296.	282.91	279.88	286.72	1.54	87.21	P
10544.	2.60	0.45	296.	282.58	280.25	285.27	2.06	87.21	P
6253.	1.99	0.52	296.	282.20	280.50	284.23	2.66	87.21	P
3874.	1.70	0.54	296.	281.99	280.56	283.51	3.00	87.21	P
6286.	1.40	0.58	296.	281.56	280.18	282.94	3.69	87.21	P
5489.	1.14	0.61	296.	281.35	280.23	282.47	4.03	87.21	P
4120.	0.75	0.64	296.	280.98	280.28	281.71	4.61	87.21	P
2841.	0.43	0.67	296.	280.64	280.26	281.42	5.15	87.21	P
1515.	0.17	0.68	296.	280.29	280.18	281.09	5.72	87.21	P
54.	0.00	0.69	296.	279.90	280.02	281.06	6.34	87.21	P
22804.	4.98	0.10	299.	283.69	278.63	291.40	0.35	87.21	P

18421.	4.01	0.26	299.	283.30	279.39	288.48	0.97	87.21	P
14361.	3.22	0.37	299.	282.94	279.95	286.72	1.54	87.21	P
10617.	2.59	0.45	299.	282.62	280.31	285.27	2.06	87.21	P
6282.	1.97	0.52	299.	282.24	280.56	284.23	2.66	87.21	P
3879.	1.69	0.54	299.	282.03	280.62	283.52	3.00	87.21	P
6325.	1.38	0.58	299.	281.59	280.24	282.96	3.69	87.21	P
5521.	1.12	0.61	299.	281.38	280.30	282.48	4.03	87.21	P
4143.	0.72	0.64	299.	281.01	280.35	281.73	4.61	87.21	P
2856.	0.41	0.67	299.	280.67	280.33	281.44	5.15	87.21	P
1521.	0.14	0.68	299.	280.32	280.25	281.11	5.72	87.21	P
50.	-.09	0.69	299.	279.93	280.09	281.08	6.34	87.21	P
18936.	4.66	0.16	157.	283.72	278.89	290.45	0.35	87.21	P
15100.	3.50	0.40	157.	283.54	280.18	288.00	0.97	87.21	P
11546.	2.58	0.58	157.	283.38	281.13	286.52	1.54	87.21	P
8269.	1.88	0.71	157.	283.23	281.78	285.30	2.06	87.21	P
4475.	1.24	0.80	157.	283.05	282.25	284.51	2.66	87.21	P
2372.	0.98	0.83	157.	282.96	282.37	284.01	3.00	87.21	P
3913.	0.61	0.88	157.	282.76	282.36	283.65	3.69	87.21	P
3332.	0.38	0.91	157.	282.66	282.50	283.38	4.03	87.21	P
2334.	0.04	0.95	157.	282.49	282.67	282.93	4.61	87.21	P
1402.	-.19	0.97	157.	282.33	282.74	282.78	5.15	87.21	P
436.	-.36	0.98	157.	282.17	282.74	282.62	5.72	87.21	P
11520.	4.07	0.16	96.	283.46	279.16	287.69	0.35	87.21	P
9046.	2.97	0.40	96.	283.39	280.45	286.10	0.97	87.21	P
6754.	2.13	0.58	96.	283.33	281.39	285.22	1.54	87.21	P
4642.	1.50	0.69	96.	283.27	282.03	284.51	2.06	87.21	P
2197.	0.96	0.78	96.	283.20	282.47	284.07	2.66	87.21	P
843.	0.75	0.80	96.	283.16	282.58	283.81	3.00	87.21	P
2068.	0.43	0.83	96.	283.09	282.67	283.60	3.69	87.21	P
1696.	0.24	0.85	96.	283.05	282.81	283.50	4.03	87.21	P
1058.	-.00	0.89	96.	282.98	282.97	283.24	4.61	87.21	P
462.	-.15	0.90	96.	282.92	283.03	283.19	5.15	87.21	P
1264.	1.23	0.00	220.	279.54	278.35	281.03	0.35	87.21	C
2137.	1.55	0.02	220.	279.99	278.43	281.16	0.97	87.21	C
2944.	1.80	0.05	220.	280.41	278.54	281.48	1.54	87.21	C
3687.	2.01	0.07	220.	280.80	278.69	282.02	2.06	87.21	C
4545.	2.20	0.12	220.	281.25	278.90	282.55	2.66	87.21	C
5019.	2.29	0.14	220.	281.50	279.04	283.11	3.00	87.21	C
9263.	2.43	0.22	220.	282.01	279.37	283.65	3.69	87.21	C
9707.	2.44	0.28	220.	282.26	279.64	284.70	4.03	87.21	C
10468.	2.43	0.38	220.	282.70	280.12	286.31	4.61	87.21	C
11177.	2.39	0.48	220.	283.10	280.59	287.62	5.15	87.21	C
11912.	2.33	0.59	220.	283.52	281.10	289.32	5.72	87.21	C
12720.	2.22	0.72	220.	283.98	281.68	290.87	6.34	87.21	C
2115.	1.17	0.01	221.	279.70	278.55	281.15	0.35	87.21	C

2796.	1.50	0.03	221.	280.18	278.67	281.40	0.97	87.21	C
3426.	1.76	0.06	221.	280.62	278.81	281.74	1.54	87.21	C
4005.	1.98	0.10	221.	281.03	278.97	282.30	2.06	87.21	C
4674.	2.20	0.14	221.	281.50	279.20	282.83	2.66	87.21	C
5044.	2.30	0.17	221.	281.77	279.34	283.41	3.00	87.21	C
9220.	2.47	0.25	221.	282.30	279.66	283.94	3.69	87.21	C
9700.	2.50	0.30	221.	282.57	279.93	285.01	4.03	87.21	C
10524.	2.51	0.40	221.	283.03	280.41	286.54	4.61	87.21	C
11291.	2.50	0.50	221.	283.45	280.88	287.82	5.15	87.21	C
12086.	2.45	0.61	221.	283.89	281.39	289.49	5.72	87.21	C
12960.	2.37	0.75	221.	284.38	281.99	291.06	6.34	87.21	C
1636.	0.86	0.01	304.	279.23	278.37	280.57	0.35	87.21	C
2335.	1.19	0.02	304.	279.64	278.44	280.76	0.97	87.21	C
2982.	1.46	0.04	304.	280.02	278.52	281.04	1.54	87.21	C
3577.	1.70	0.06	304.	280.37	278.62	281.54	2.06	87.21	C
4264.	1.94	0.09	304.	280.78	278.75	282.02	2.66	87.21	C
4645.	2.07	0.11	304.	281.01	278.84	282.56	3.00	87.21	C
9179.	2.33	0.16	304.	281.47	278.99	283.05	3.69	87.21	C
9820.	2.39	0.20	304.	281.70	279.18	284.10	4.03	87.21	C
10918.	2.49	0.28	304.	282.09	279.51	285.75	4.61	87.21	C
11942.	2.57	0.35	304.	282.46	279.83	287.12	5.15	87.21	C
13001.	2.63	0.44	304.	282.84	280.17	288.93	5.72	87.21	C
14166.	2.68	0.54	304.	283.26	280.56	290.64	6.34	87.21	C
1549.	0.96	0.01	298.	279.37	278.42	280.61	0.35	87.21	C
2269.	1.26	0.02	298.	279.76	278.48	280.79	0.97	87.21	C
2934.	1.51	0.04	298.	280.12	278.56	281.08	1.54	87.21	C
3546.	1.72	0.06	298.	280.45	278.66	281.57	2.06	87.21	C
4253.	1.93	0.09	298.	280.83	278.80	282.06	2.66	87.21	C
4644.	2.04	0.11	298.	281.04	278.89	282.60	3.00	87.21	C
8995.	2.26	0.16	298.	281.48	279.05	283.11	3.69	87.21	C
9728.	2.31	0.20	298.	281.70	279.24	284.15	4.03	87.21	C
10984.	2.37	0.28	298.	282.07	279.58	285.82	4.61	87.21	C
12154.	2.41	0.36	298.	282.41	279.91	287.20	5.15	87.21	C
13365.	2.43	0.45	298.	282.77	280.27	289.06	5.72	87.21	C
14697.	2.42	0.56	298.	283.16	280.70	290.87	6.34	87.21	C
1798.	1.26	0.01	168.	279.45	278.15	280.74	0.35	87.21	C
2316.	1.51	0.04	168.	279.87	278.29	280.96	0.97	87.21	C
2793.	1.71	0.07	168.	280.27	278.44	281.27	1.54	87.21	C
3233.	1.87	0.11	168.	280.63	278.62	281.77	2.06	87.21	C
3741.	2.02	0.15	168.	281.04	278.85	282.24	2.66	87.21	C
4022.	2.08	0.18	168.	281.27	279.00	282.72	3.00	87.21	C
6941.	2.16	0.26	168.	281.75	279.36	283.14	3.69	87.21	C
7152.	2.15	0.32	168.	281.98	279.63	284.01	4.03	87.21	C
7513.	2.10	0.41	168.	282.38	280.11	285.19	4.61	87.21	C
7849.	2.03	0.50	168.	282.76	280.57	286.19	5.15	87.21	C

8198.	1.94	0.60	168.	283.15	281.06	287.43	5.72	87.21	C
8581.	1.81	0.72	168.	283.58	281.61	288.52	6.34	87.21	C
603.	1.65	0.01	102.	279.97	278.16	281.20	0.35	87.21	C
1230.	1.83	0.03	102.	280.33	278.26	281.24	0.97	87.21	C
1810.	1.96	0.06	102.	280.67	278.42	281.48	1.54	87.21	C
2344.	2.04	0.10	102.	280.99	278.63	281.91	2.06	87.21	C
2961.	2.08	0.15	102.	281.35	278.93	282.31	2.66	87.21	C
3302.	2.08	0.19	102.	281.55	279.13	282.68	3.00	87.21	C
4224.	2.03	0.29	102.	281.96	279.60	282.90	3.69	87.21	C
4199.	1.98	0.34	102.	282.16	279.89	283.50	4.03	87.21	C
4156.	1.88	0.43	102.	282.51	280.36	284.16	4.61	87.21	C
4116.	1.77	0.51	102.	282.83	280.79	284.73	5.15	87.21	C
4075.	1.66	0.59	102.	283.17	281.23	285.38	5.72	87.21	C
4029.	1.53	0.69	102.	283.54	281.70	285.90	6.34	87.21	C
581.	1.68	0.01	100.	280.00	278.17	281.21	0.35	87.21	C
1199.	1.85	0.03	100.	280.36	278.28	281.24	0.97	87.21	C
1770.	1.97	0.06	100.	280.70	278.44	281.48	1.54	87.21	C
2296.	2.04	0.10	100.	281.01	278.64	281.92	2.06	87.21	C
2903.	2.07	0.15	100.	281.37	278.94	282.31	2.66	87.21	C
3239.	2.07	0.19	100.	281.57	279.15	282.67	3.00	87.21	C
4164.	2.02	0.29	100.	281.97	279.62	282.90	3.69	87.21	C
4145.	1.96	0.34	100.	282.17	279.90	283.50	4.03	87.21	C
4113.	1.86	0.43	100.	282.52	280.38	284.16	4.61	87.21	C
4083.	1.76	0.51	100.	282.84	280.83	284.73	5.15	87.21	C
4051.	1.65	0.60	100.	283.18	281.27	285.39	5.72	87.21	C
4017.	1.51	0.69	100.	283.55	281.76	285.91	6.34	87.21	C
24165.	5.19	0.15	216.	284.28	278.89	292.76	0.35	87.21	P
19362.	4.02	0.38	216.	284.00	280.05	289.70	0.97	87.21	P
14912.	3.09	0.54	216.	283.74	280.91	287.76	1.54	87.21	P
10809.	2.36	0.66	216.	283.51	281.49	286.15	2.06	87.21	P
6057.	1.69	0.75	216.	283.23	281.91	285.10	2.66	87.21	P
3423.	1.40	0.78	216.	283.08	282.01	284.46	3.00	87.21	P
5492.	1.02	0.83	216.	282.77	281.86	283.95	3.69	87.21	P
4736.	0.76	0.86	216.	282.62	281.97	283.55	4.03	87.21	P
3440.	0.37	0.90	216.	282.35	282.10	282.94	4.61	87.21	P
2230.	0.08	0.93	216.	282.11	282.15	282.70	5.15	87.21	P
974.	-.16	0.94	216.	281.85	282.13	282.46	5.72	87.21	P
22510.	4.80	0.10	299.	283.66	278.79	291.56	0.35	87.21	P
18178.	3.85	0.25	299.	283.29	279.54	288.71	0.97	87.21	P
14164.	3.08	0.37	299.	282.95	280.09	286.88	1.54	87.21	P
10463.	2.47	0.45	299.	282.64	280.44	285.29	2.06	87.21	P
6176.	1.87	0.51	299.	282.28	280.69	284.23	2.66	87.21	P
3801.	1.60	0.53	299.	282.08	280.74	283.57	3.00	87.21	P
6174.	1.31	0.57	299.	281.67	280.37	283.01	3.69	87.21	P
5380.	1.06	0.60	299.	281.47	280.42	282.54	4.03	87.21	P

4018.	0.69	0.63	299.	281.12	280.46	281.82	4.61	87.21	P
2745.	0.39	0.66	299.	280.80	280.44	281.53	5.15	87.21	P
1425.	0.15	0.67	299.	280.46	280.36	281.21	5.72	87.21	P
22237.	4.82	0.10	299.	283.58	278.66	291.46	0.35	87.21	P
17926.	3.88	0.25	299.	283.21	279.40	288.55	0.97	87.21	P
13931.	3.12	0.36	299.	282.87	279.94	286.76	1.54	87.21	P
10248.	2.51	0.44	299.	282.55	280.28	285.18	2.06	87.21	P
5983.	1.92	0.50	299.	282.19	280.52	284.12	2.66	87.21	P
3619.	1.65	0.52	299.	281.99	280.56	283.46	3.00	87.21	P
5991.	1.36	0.56	299.	281.57	280.18	282.91	3.69	87.21	P
5219.	1.12	0.59	299.	281.37	280.23	282.44	4.03	87.21	P
3894.	0.74	0.62	299.	281.02	280.26	281.72	4.61	87.21	P
2657.	0.45	0.64	299.	280.69	280.24	281.43	5.15	87.21	P
1373.	0.20	0.66	299.	280.35	280.15	281.11	5.72	87.21	P
18816.	4.71	0.15	169.	283.57	278.68	290.33	0.35	87.21	P
14939.	3.60	0.37	169.	283.38	279.85	287.82	0.97	87.21	P
11346.	2.73	0.53	169.	283.22	280.71	286.33	1.54	87.21	P
8034.	2.06	0.65	169.	283.06	281.29	285.16	2.06	87.21	P
4199.	1.46	0.73	169.	282.88	281.70	284.39	2.66	87.21	P
2074.	1.21	0.75	169.	282.78	281.80	283.91	3.00	87.21	P
4033.	0.85	0.79	169.	282.58	281.75	283.52	3.69	87.21	P
3438.	0.63	0.82	169.	282.48	281.88	283.24	4.03	87.21	P
2418.	0.29	0.86	169.	282.30	282.04	282.76	4.61	87.21	P
1465.	0.06	0.88	169.	282.14	282.10	282.60	5.15	87.21	P
477.	-.12	0.90	169.	281.97	282.10	282.43	5.72	87.21	P
11090.	3.89	0.14	105.	282.90	278.81	287.19	0.35	87.21	P
8801.	2.90	0.35	105.	282.81	279.94	285.68	0.97	87.21	P
6680.	2.13	0.51	105.	282.73	280.77	284.77	1.54	87.21	P
4726.	1.55	0.61	105.	282.66	281.34	284.05	2.06	87.21	P
2464.	1.04	0.69	105.	282.58	281.76	283.56	2.66	87.21	P
1210.	0.82	0.71	105.	282.53	281.87	283.28	3.00	87.21	P
2429.	0.49	0.75	105.	282.44	281.98	283.03	3.69	87.21	P
2009.	0.30	0.78	105.	282.39	282.12	282.92	4.03	87.21	P
1288.	0.04	0.81	105.	282.31	282.30	282.61	4.61	87.21	P
615.	-.12	0.83	105.	282.24	282.37	282.54	5.15	87.21	P
11420.	3.98	0.14	106.	283.15	278.95	287.54	0.35	87.21	P
9052.	2.97	0.36	106.	283.07	280.10	285.99	0.97	87.21	P
6858.	2.19	0.52	106.	282.99	280.94	285.05	1.54	87.21	P
4836.	1.59	0.62	106.	282.92	281.52	284.30	2.06	87.21	P
2495.	1.07	0.70	106.	282.83	281.94	283.81	2.66	87.21	P
1199.	0.86	0.72	106.	282.78	282.06	283.53	3.00	87.21	P
2446.	0.52	0.76	106.	282.69	282.16	283.27	3.69	87.21	P
2023.	0.33	0.79	106.	282.64	282.31	283.15	4.03	87.21	P
1296.	0.07	0.82	106.	282.56	282.48	282.85	4.61	87.21	P
618.	-.09	0.84	106.	282.48	282.55	282.78	5.15	87.21	P

18270.	4.79	0.14	169.	283.78	278.80	290.52	0.35	87.21	P
14634.	3.69	0.36	169.	283.59	279.94	288.12	0.97	87.21	P
11265.	2.81	0.52	169.	283.40	280.78	286.61	1.54	87.21	P
8159.	2.14	0.63	169.	283.23	281.36	285.36	2.06	87.21	P
4562.	1.52	0.72	169.	283.04	281.78	284.54	2.66	87.21	P
2569.	1.25	0.75	169.	282.93	281.90	284.04	3.00	87.21	P
4082.	0.87	0.79	169.	282.71	281.88	283.64	3.69	87.21	P
3485.	0.63	0.82	169.	282.60	282.00	283.35	4.03	87.21	P
2460.	0.29	0.86	169.	282.41	282.16	282.88	4.61	87.21	P
1504.	0.04	0.88	169.	282.24	282.23	282.72	5.15	87.21	P
511.	-.15	0.90	169.	282.05	282.23	282.55	5.72	87.21	P
2093.	1.41	0.01	213.	279.59	278.22	280.98	0.35	87.21	C
2678.	1.71	0.03	213.	280.04	278.34	281.25	0.97	87.21	C
3218.	1.95	0.06	213.	280.47	278.49	281.59	1.54	87.21	C
3715.	2.14	0.09	213.	280.86	278.64	282.14	2.06	87.21	C
4289.	2.33	0.14	213.	281.31	278.86	282.62	2.66	87.21	C
4607.	2.42	0.16	213.	281.56	278.99	283.18	3.00	87.21	C
8967.	2.56	0.24	213.	282.08	279.31	283.75	3.69	87.21	C
9393.	2.56	0.30	213.	282.33	279.58	284.80	4.03	87.21	C
10123.	2.54	0.40	213.	282.77	280.06	286.35	4.61	87.21	C
10804.	2.50	0.49	213.	283.17	280.53	287.67	5.15	87.21	C
11509.	2.42	0.60	213.	283.60	281.04	289.36	5.72	87.21	C
12284.	2.31	0.74	213.	284.06	281.62	290.92	6.34	87.21	C
2009.	1.53	0.01	217.	279.73	278.36	281.10	0.35	87.21	C
2581.	1.79	0.03	217.	280.18	278.48	281.36	0.97	87.21	C
3110.	2.00	0.06	217.	280.60	278.61	281.70	1.54	87.21	C
3596.	2.17	0.09	217.	280.98	278.76	282.24	2.06	87.21	C
4159.	2.34	0.13	217.	281.43	278.96	282.72	2.66	87.21	C
4470.	2.42	0.15	217.	281.67	279.09	283.27	3.00	87.21	C
8723.	2.55	0.23	217.	282.18	279.39	283.83	3.69	87.21	C
9140.	2.55	0.28	217.	282.43	279.65	284.87	4.03	87.21	C
9855.	2.54	0.37	217.	282.86	280.11	286.41	4.61	87.21	C
10521.	2.51	0.47	217.	283.26	280.55	287.71	5.15	87.21	C
11211.	2.45	0.58	217.	283.67	281.03	289.39	5.72	87.21	C
11969.	2.36	0.70	217.	284.13	281.59	290.94	6.34	87.21	C
2136.	1.27	0.01	217.	279.36	278.13	280.82	0.35	87.21	C
2803.	1.58	0.03	217.	279.84	278.26	281.09	0.97	87.21	C
3420.	1.84	0.06	217.	280.28	278.41	281.44	1.54	87.21	C
3987.	2.04	0.10	217.	280.69	278.57	282.00	2.06	87.21	C
4642.	2.25	0.14	217.	281.17	278.80	282.54	2.66	87.21	C
5005.	2.35	0.17	217.	281.43	278.94	283.14	3.00	87.21	C
8717.	2.52	0.25	217.	281.97	279.25	283.68	3.69	87.21	C
9171.	2.54	0.30	217.	282.23	279.51	284.69	4.03	87.21	C
9949.	2.56	0.39	217.	282.69	279.97	286.21	4.61	87.21	C
10674.	2.55	0.49	217.	283.11	280.42	287.48	5.15	87.21	C

11424.	2.52	0.60	217.	283.55	280.91	289.12	5.72	87.21	C
12250.	2.46	0.73	217.	284.04	281.47	290.65	6.34	87.21	C
2139.	1.39	0.01	219.	279.42	278.20	280.89	0.35	87.21	C
2820.	1.67	0.03	219.	279.90	278.33	281.15	0.97	87.21	C
3450.	1.90	0.06	219.	280.35	278.48	281.50	1.54	87.21	C
4030.	2.09	0.09	219.	280.76	278.64	282.06	2.06	87.21	C
4699.	2.27	0.14	219.	281.24	278.87	282.61	2.66	87.21	C
5069.	2.36	0.17	219.	281.50	279.01	283.21	3.00	87.21	C
8871.	2.52	0.25	219.	282.04	279.33	283.75	3.69	87.21	C
9348.	2.54	0.30	219.	282.31	279.59	284.76	4.03	87.21	C
10165.	2.55	0.40	219.	282.77	280.05	286.30	4.61	87.21	C
10926.	2.54	0.49	219.	283.19	280.51	287.58	5.15	87.21	C
11715.	2.51	0.60	219.	283.64	281.00	289.24	5.72	87.21	C
12582.	2.45	0.73	219.	284.13	281.58	290.80	6.34	87.21	C

APPENDIX B3

Convective boiling of R450A within a micro-fin tube
(file: hqgwp3b.dat)

q" (Wm^{-2})	ΔT_s (K)	x_q	G_r (kg m^{-2}s^{-1})	T_w (K)	T_s (K)	T_f (K)	z (m)	M_w (g/mole)	flow
1028.	0.26	0.01	208.	277.72	277.34	278.70	0.35	63.52	C
1754.	0.50	0.02	208.	277.95	277.34	278.77	0.97	63.52	C
2426.	0.71	0.03	208.	278.16	277.35	278.98	1.54	63.52	C
3044.	0.90	0.05	208.	278.35	277.36	279.35	2.06	63.52	C
3758.	1.11	0.08	208.	278.57	277.38	279.71	2.66	63.52	C
4154.	1.23	0.10	208.	278.70	277.39	280.06	3.00	63.52	C
7716.	1.48	0.15	208.	278.95	277.36	280.36	3.69	63.52	C
8649.	1.59	0.19	208.	279.08	277.39	281.11	4.03	63.52	C
10246.	1.77	0.26	208.	279.29	277.42	282.29	4.61	63.52	C
11735.	1.94	0.35	208.	279.49	277.45	283.32	5.15	63.52	C
13276.	2.11	0.44	208.	279.70	277.47	284.73	5.72	63.52	C
14971.	2.29	0.57	208.	279.93	277.51	286.17	6.34	63.52	C
664.	0.30	0.00	292.	278.25	277.83	279.14	0.35	63.52	C
1358.	0.50	0.01	292.	278.44	277.83	279.18	0.97	63.52	C
2000.	0.69	0.02	292.	278.62	277.83	279.35	1.54	63.52	C
2591.	0.86	0.03	292.	278.78	277.83	279.70	2.06	63.52	C
3274.	1.06	0.05	292.	278.97	277.84	280.03	2.66	63.52	C
3652.	1.16	0.06	292.	279.07	277.84	280.34	3.00	63.52	C
7148.	1.42	0.09	292.	279.28	277.77	280.64	3.69	63.52	C
8139.	1.52	0.12	292.	279.39	277.78	281.37	4.03	63.52	C
9835.	1.70	0.17	292.	279.57	277.78	282.51	4.61	63.52	C
11415.	1.88	0.23	292.	279.73	277.77	283.55	5.15	63.52	C
13052.	2.07	0.29	292.	279.91	277.74	284.99	5.72	63.52	C
14850.	2.28	0.38	292.	280.10	277.70	286.47	6.34	63.52	C
647.	0.43	0.00	151.	278.57	278.16	279.47	0.35	63.52	C
1293.	0.59	0.01	151.	278.77	278.16	279.50	0.97	63.52	C
1891.	0.74	0.03	151.	278.95	278.17	279.67	1.54	63.52	C
2442.	0.88	0.05	151.	279.12	278.19	280.00	2.06	63.52	C
3078.	1.03	0.08	151.	279.31	278.20	280.31	2.66	63.52	C
3430.	1.11	0.10	151.	279.42	278.22	280.60	3.00	63.52	C
6245.	1.28	0.16	151.	279.64	278.22	280.85	3.69	63.52	C
6908.	1.36	0.21	151.	279.75	278.25	281.50	4.03	63.52	C
8044.	1.48	0.29	151.	279.94	278.30	282.44	4.61	63.52	C
9103.	1.58	0.38	151.	280.11	278.35	283.35	5.15	63.52	C
10199.	1.69	0.48	151.	280.29	278.42	284.45	5.72	63.52	C
11404.	1.79	0.61	151.	280.49	278.51	285.58	6.34	63.52	C
424.	0.43	0.00	104.	278.35	277.93	279.12	0.35	63.52	C
906.	0.55	0.01	104.	278.50	277.94	279.13	0.97	63.52	C

1352.	0.66	0.03	104.	278.64	277.95	279.26	1.54	63.52	C
1762.	0.75	0.05	104.	278.77	277.97	279.54	2.06	63.52	C
2236.	0.85	0.09	104.	278.92	277.99	279.77	2.66	63.52	C
2498.	0.90	0.11	104.	279.01	278.00	279.98	3.00	63.52	C
3921.	1.01	0.17	104.	279.18	278.02	280.11	3.69	63.52	C
4362.	1.05	0.20	104.	279.26	278.05	280.60	4.03	63.52	C
5119.	1.12	0.28	104.	279.41	278.11	281.14	4.61	63.52	C
5825.	1.17	0.36	104.	279.54	278.17	281.76	5.15	63.52	C
6556.	1.22	0.46	104.	279.68	278.24	282.47	5.72	63.52	C
7360.	1.26	0.58	104.	279.84	278.34	283.21	6.34	63.52	C
19679.	2.99	0.09	222.	280.96	278.05	286.93	0.35	63.52	P
16147.	2.58	0.23	222.	280.66	278.14	284.97	0.97	63.52	P
12874.	2.22	0.34	222.	280.37	278.20	283.64	1.54	63.52	P
9857.	1.91	0.41	222.	280.11	278.24	282.48	2.06	63.52	P
6363.	1.58	0.48	222.	279.81	278.26	281.63	2.66	63.52	P
4427.	1.40	0.50	222.	279.64	278.26	281.08	3.00	63.52	P
6850.	1.18	0.55	222.	279.29	278.01	280.59	3.69	63.52	P
5983.	1.01	0.58	222.	279.12	278.00	280.22	4.03	63.52	P
4496.	0.75	0.62	222.	278.83	277.98	279.55	4.61	63.52	P
3108.	0.52	0.65	222.	278.56	277.94	279.30	5.15	63.52	P
1668.	0.30	0.67	222.	278.28	277.88	279.00	5.72	63.52	P
82.	0.08	0.68	222.	277.97	277.78	278.98	6.34	63.52	P
19409.	2.95	0.07	291.	281.21	278.29	287.08	0.35	63.52	P
15943.	2.57	0.17	291.	280.88	278.34	285.13	0.97	63.52	P
12733.	2.23	0.25	291.	280.57	278.37	283.80	1.54	63.52	P
9774.	1.94	0.31	291.	280.28	278.38	282.65	2.06	63.52	P
6346.	1.62	0.36	291.	279.95	278.36	281.80	2.66	63.52	P
4447.	1.46	0.38	291.	279.77	278.34	281.25	3.00	63.52	P
7198.	1.28	0.42	291.	279.39	277.99	280.73	3.69	63.52	P
6291.	1.12	0.44	291.	279.20	277.97	280.35	4.03	63.52	P
4734.	0.87	0.47	291.	278.89	277.91	279.64	4.61	63.52	P
3280.	0.65	0.49	291.	278.59	277.84	279.36	5.15	63.52	P
1772.	0.44	0.51	291.	278.28	277.75	279.04	5.72	63.52	P
11220.	0.23	0.52	291.	277.94	277.62	279.01	6.34	63.52	P
15712.	2.57	0.10	163.	281.03	278.51	286.00	0.35	63.52	P
12842.	2.21	0.25	163.	280.80	278.62	284.36	0.97	63.52	P
10183.	1.90	0.37	163.	280.58	278.71	283.27	1.54	63.52	P
7731.	1.63	0.45	163.	280.38	278.78	282.34	2.06	63.52	P
4893.	1.33	0.52	163.	280.16	278.83	281.64	2.66	63.52	P
3320.	1.18	0.55	163.	280.03	278.84	281.20	3.00	63.52	P
5285.	0.95	0.60	163.	279.77	278.72	280.80	3.69	63.52	P
4572.	0.80	0.63	163.	279.64	278.74	280.52	4.03	63.52	P
3349.	0.57	0.67	163.	279.42	278.75	279.99	4.61	63.52	P
2206.	0.37	0.70	163.	279.22	278.75	279.80	5.15	63.52	P
1021.	0.18	0.72	163.	279.00	278.72	279.58	5.72	63.52	P

12397.	1.98	0.13	100.	280.10	278.10	283.79	0.35	63.52	P
10132.	1.68	0.32	100.	279.95	278.26	282.62	0.97	63.52	P
8034.	1.41	0.47	100.	279.81	278.41	281.87	1.54	63.52	P
6100.	1.18	0.58	100.	279.68	278.53	281.25	2.06	63.52	P
3862.	0.93	0.67	100.	279.53	278.64	280.75	2.66	63.52	P
2622.	0.80	0.70	100.	279.44	278.69	280.43	3.00	63.52	P
4421.	0.58	0.77	100.	279.27	278.70	280.12	3.69	63.52	P
3784.	0.45	0.82	100.	279.19	278.76	279.95	4.03	63.52	P
2691.	0.24	0.88	100.	279.04	278.85	279.52	4.61	63.52	P
1671.	0.07	0.91	100.	278.91	278.89	279.40	5.15	63.52	P
612.	-.08	0.93	100.	278.77	278.89	279.26	5.72	63.52	P
865.	0.43	0.00	220.	278.27	277.86	279.21	0.35	63.52	C
1670.	0.61	0.01	220.	278.49	277.86	279.27	0.97	63.52	C
2415.	0.78	0.03	220.	278.68	277.87	279.47	1.54	63.52	C
3100.	0.94	0.05	220.	278.86	277.88	279.83	2.06	63.52	C
3892.	1.12	0.07	220.	279.07	277.89	280.18	2.66	63.52	C
4331.	1.21	0.09	220.	279.19	277.90	280.55	3.00	63.52	C
7678.	1.43	0.14	220.	279.42	277.89	280.84	3.69	63.52	C
8723.	1.53	0.18	220.	279.54	277.91	281.61	4.03	63.52	C
10513.	1.69	0.25	220.	279.74	277.94	282.77	4.61	63.52	C
12181.	1.85	0.33	220.	279.93	277.96	283.84	5.15	63.52	C
13908.	2.01	0.43	220.	280.12	277.99	285.29	5.72	63.52	C
15807.	2.19	0.55	220.	280.34	278.01	286.80	6.34	63.52	C
811.	0.45	0.00	300.	278.27	277.87	279.16	0.35	63.52	C
1544.	0.61	0.01	300.	278.46	277.86	279.22	0.97	63.52	C
2222.	0.76	0.02	300.	278.64	277.86	279.40	1.54	63.52	C
2846.	0.91	0.03	300.	278.80	277.87	279.75	2.06	63.52	C
3567.	1.08	0.05	300.	278.99	277.87	280.08	2.66	63.52	C
3965.	1.17	0.06	300.	279.10	277.87	280.43	3.00	63.52	C
7188.	1.41	0.10	300.	279.31	277.81	280.71	3.69	63.52	C
8288.	1.51	0.12	300.	279.42	277.82	281.45	4.03	63.52	C
10172.	1.69	0.17	300.	279.60	277.81	282.58	4.61	63.52	C
11927.	1.86	0.23	300.	279.77	277.80	283.64	5.15	63.52	C
13745.	2.06	0.30	300.	279.94	277.78	285.10	5.72	63.52	C
15743.	2.28	0.38	300.	280.14	277.74	286.63	6.34	63.52	C
428.	0.41	0.00	157.	278.37	277.97	279.33	0.35	63.52	C
1242.	0.59	0.01	157.	278.58	277.98	279.34	0.97	63.52	C
1995.	0.76	0.03	157.	278.78	277.99	279.53	1.54	63.52	C
2688.	0.91	0.05	157.	278.96	278.00	279.86	2.06	63.52	C
3488.	1.07	0.08	157.	279.17	278.02	280.18	2.66	63.52	C
3932.	1.16	0.10	157.	279.28	278.04	280.52	3.00	63.52	C
6197.	1.35	0.17	157.	279.52	278.04	280.78	3.69	63.52	C
6971.	1.43	0.21	157.	279.64	278.07	281.44	4.03	63.52	C
8297.	1.56	0.29	157.	279.84	278.12	282.38	4.61	63.52	C
9533.	1.68	0.38	157.	280.02	278.17	283.24	5.15	63.52	C

10813.	1.80	0.48	157.	280.22	278.23	284.41	5.72	63.52	C
12220.	1.91	0.62	157.	280.43	278.33	285.63	6.34	63.52	C
205.	0.41	0.00	99.	278.71	278.31	279.54	0.35	63.52	C
819.	0.55	0.01	99.	278.88	278.31	279.53	0.97	63.52	C
1387.	0.67	0.03	99.	279.04	278.32	279.67	1.54	63.52	C
1910.	0.78	0.05	99.	279.19	278.34	279.93	2.06	63.52	C
2514.	0.90	0.09	99.	279.36	278.37	280.17	2.66	63.52	C
2849.	0.96	0.11	99.	279.46	278.38	280.41	3.00	63.52	C
3870.	1.09	0.18	99.	279.65	278.40	280.55	3.69	63.52	C
4333.	1.15	0.22	99.	279.75	278.44	281.03	4.03	63.52	C
5125.	1.23	0.30	99.	279.91	278.50	281.58	4.61	63.52	C
5864.	1.30	0.39	99.	280.07	278.57	282.14	5.15	63.52	C
6629.	1.37	0.49	99.	280.23	278.65	282.88	5.72	63.52	C
7470.	1.42	0.62	99.	280.40	278.78	283.64	6.34	63.52	C
189.	0.50	0.00	100.	278.86	278.36	279.70	0.35	63.52	C
809.	0.58	0.01	100.	279.03	278.48	279.69	0.97	63.52	C
1383.	0.69	0.03	100.	279.19	278.49	279.82	1.54	63.52	C
1910.	0.79	0.05	100.	279.34	278.50	280.09	2.06	63.52	C
2520.	0.90	0.09	100.	279.51	278.53	280.32	2.66	63.52	C
2858.	0.96	0.11	100.	279.61	278.55	280.57	3.00	63.52	C
3836.	1.08	0.18	100.	279.80	278.57	280.69	3.69	63.52	C
4299.	1.13	0.22	100.	279.90	278.61	281.17	4.03	63.52	C
5092.	1.21	0.30	100.	280.07	278.67	281.72	4.61	63.52	C
5831.	1.29	0.38	100.	280.22	278.74	282.28	5.15	63.52	C
6596.	1.35	0.48	100.	280.38	278.82	283.02	5.72	63.52	C
7439.	1.41	0.61	100.	280.56	278.94	283.77	6.34	63.52	C
20314.	2.94	0.10	219.	280.75	277.80	286.97	0.35	63.52	P
16667.	2.55	0.24	219.	280.43	277.90	284.89	0.97	63.52	P
13288.	2.20	0.35	219.	280.15	277.97	283.53	1.54	63.52	P
10173.	1.89	0.44	219.	279.88	278.01	282.35	2.06	63.52	P
6565.	1.56	0.50	219.	279.57	278.03	281.47	2.66	63.52	P
4566.	1.39	0.53	219.	279.40	278.03	280.88	3.00	63.52	P
6796.	1.17	0.58	219.	279.05	277.78	280.39	3.69	63.52	P
5944.	1.01	0.61	219.	278.88	277.78	280.01	4.03	63.52	P
4484.	0.74	0.65	219.	278.58	277.76	279.33	4.61	63.52	P
3120.	0.50	0.68	219.	278.31	277.72	279.07	5.15	63.52	P
1704.	0.27	0.70	219.	278.02	277.66	278.77	5.72	63.52	P
145.	0.05	0.71	219.	277.71	277.57	278.74	6.34	63.52	P
19520.	2.94	0.07	294.	281.06	278.14	286.89	0.35	63.52	P
16016.	2.56	0.17	294.	280.73	278.19	284.92	0.97	63.52	P
12770.	2.23	0.25	294.	280.42	278.22	283.63	1.54	63.52	P
9777.	1.94	0.31	294.	280.13	278.23	282.49	2.06	63.52	P
6311.	1.63	0.36	294.	279.80	278.21	281.65	2.66	63.52	P
4390.	1.46	0.38	294.	279.62	278.19	281.10	3.00	63.52	P
6987.	1.29	0.41	294.	279.25	277.84	280.59	3.69	63.52	P

6140.	1.14	0.44	294.	279.06	277.81	280.20	4.03	63.52	P
4685.	0.89	0.47	294.	278.74	277.75	279.51	4.61	63.52	P
3327.	0.67	0.49	294.	278.45	277.68	279.24	5.15	63.52	P
1918.	0.47	0.50	294.	278.14	277.58	278.92	5.72	63.52	P
365.	0.27	0.51	294.	277.80	277.45	278.87	6.34	63.52	P
17093.	2.60	0.11	162.	281.29	278.67	286.58	0.35	63.52	P
13985.	2.24	0.28	162.	281.05	278.80	284.84	0.97	63.52	P
11107.	1.93	0.40	162.	280.83	278.90	283.70	1.54	63.52	P
8453.	1.65	0.50	162.	280.63	278.98	282.71	2.06	63.52	P
5381.	1.36	0.57	162.	280.40	279.04	282.01	2.66	63.52	P
3678.	1.21	0.60	162.	280.27	279.06	281.53	3.00	63.52	P
5593.	0.98	0.66	162.	280.01	278.94	281.13	3.69	63.52	P
4854.	0.83	0.69	162.	279.88	278.97	280.83	4.03	63.52	P
3585.	0.59	0.74	162.	279.65	278.99	280.27	4.61	63.52	P
2401.	0.38	0.77	162.	279.44	278.99	280.06	5.15	63.52	P
1172.	0.18	0.79	162.	279.23	278.97	279.84	5.72	63.52	P
11120.	2.03	0.11	104.	280.56	278.51	284.16	0.35	63.52	P
9056.	1.73	0.28	104.	280.41	278.65	282.99	0.97	63.52	P
7145.	1.47	0.41	104.	280.26	278.77	282.24	1.54	63.52	P
5384.	1.25	0.50	104.	280.13	278.87	281.62	2.06	63.52	P
3345.	1.01	0.58	104.	279.98	278.95	281.13	2.66	63.52	P
2215.	0.89	0.60	104.	279.90	278.98	280.82	3.00	63.52	P
3886.	0.68	0.66	104.	279.72	278.97	280.51	3.69	63.52	P
3305.	0.56	0.69	104.	279.64	279.01	280.35	4.03	63.52	P
2308.	0.36	0.74	104.	279.49	279.07	279.93	4.61	63.52	P
1378.	0.20	0.77	104.	279.36	279.09	279.82	5.15	63.52	P
412.	0.05	0.79	104.	279.21	279.08	279.68	5.72	63.52	P
11347.	2.06	0.12	102.	280.42	278.35	284.01	0.35	63.52	P
9252.	1.76	0.29	102.	280.27	278.49	282.83	0.97	63.52	P
7312.	1.49	0.43	102.	280.13	278.62	282.11	1.54	63.52	P
5524.	1.25	0.52	102.	279.99	278.73	281.49	2.06	63.52	P
3454.	1.00	0.60	102.	279.84	278.82	281.01	2.66	63.52	P
2308.	0.88	0.63	102.	279.76	278.85	280.69	3.00	63.52	P
3887.	0.66	0.69	102.	279.58	278.85	280.38	3.69	63.52	P
3325.	0.53	0.73	102.	279.50	278.90	280.23	4.03	63.52	P
2362.	0.33	0.78	102.	279.35	278.96	279.81	4.61	63.52	P
1463.	0.16	0.81	102.	279.22	278.99	279.70	5.15	63.52	P
530.	0.01	0.82	102.	279.07	278.98	279.56	5.72	63.52	P
523.	0.65	0.00	103.	278.97	278.31	279.52	0.97	63.52	C
1183.	0.74	0.02	103.	279.10	278.31	279.64	1.54	63.52	C
1790.	0.81	0.04	103.	279.22	278.33	279.89	2.06	63.52	C
2492.	0.90	0.07	103.	279.36	278.35	280.12	2.66	63.52	C
2880.	0.94	0.10	103.	279.44	278.37	280.36	3.00	63.52	C
3795.	1.05	0.16	103.	279.60	278.38	280.47	3.69	63.52	C
4202.	1.08	0.20	103.	279.68	278.42	280.92	4.03	63.52	C

4899.	1.15	0.27	103.	279.81	278.47	281.48	4.61	63.52	C
5549.	1.20	0.35	103.	279.94	278.53	282.02	5.15	63.52	C
6223.	1.26	0.44	103.	280.07	278.60	282.71	5.72	63.52	C
6963.	1.31	0.56	103.	280.21	278.70	283.39	6.34	63.52	C
10232.	2.06	0.11	99.	280.32	278.25	283.64	0.35	63.52	P
8312.	1.76	0.27	99.	280.17	278.38	282.52	0.97	63.52	P
6533.	1.49	0.39	99.	280.02	278.49	281.85	1.54	63.52	P
4894.	1.26	0.48	99.	279.89	278.58	281.32	2.06	63.52	P
2997.	1.02	0.55	99.	279.74	278.66	280.88	2.66	63.52	P
1945.	0.90	0.57	99.	279.65	278.69	280.58	3.00	63.52	P
3714.	0.69	0.63	99.	279.48	278.69	280.28	3.69	63.52	P
3168.	0.56	0.67	99.	279.39	278.73	280.12	4.03	63.52	P
2232.	0.37	0.71	99.	279.25	278.79	279.71	4.61	63.52	P
1358.	0.20	0.74	99.	279.11	278.81	279.60	5.15	63.52	P
452.	0.06	0.76	99.	278.97	278.80	279.47	5.72	63.52	P
666.	0.64	0.01	107.	279.02	278.35	279.63	0.97	63.52	C
1280.	0.73	0.02	107.	279.16	278.36	279.74	1.54	63.52	C
1845.	0.82	0.04	107.	279.29	278.37	280.01	2.06	63.52	C
2498.	0.91	0.08	107.	279.43	278.40	280.24	2.66	63.52	C
2859.	0.96	0.10	107.	279.51	278.41	280.47	3.00	63.52	C
3836.	1.08	0.16	107.	279.68	278.43	280.58	3.69	63.52	C
4263.	1.12	0.20	107.	279.76	278.46	281.03	4.03	63.52	C
4994.	1.20	0.27	107.	279.90	278.52	281.57	4.61	63.52	C
5675.	1.26	0.35	107.	280.04	278.58	282.11	5.15	63.52	C
6381.	1.33	0.44	107.	280.17	278.64	282.80	5.72	63.52	C
7158.	1.39	0.55	107.	280.32	278.73	283.48	6.34	63.52	C

APPENDIX C1
Fanning Friction Factor Measurements

Fanning friction factor (f) measurements were made following the procedure outlined by Kedzierski and Goncalves (1999):

$$f = \frac{D_h}{(\nu_o + \nu_i)\Delta L}\left(\frac{(P_i - P_o)}{G^2} - (\nu_o - \nu_i)\right) \tag{C1}$$

where the specific volume of the fluid (ν) was calculated from the thermodynamic quality weighted average of the liquid and vapor specific volumes for the exit (subscript o) and the inlet (subscript i) of each incremental length (ΔL). The P_i and the P_o are saturation pressures for the inlet and exit of the increment, respectively. The mass velocity (G) is the total liquid and vapor mass flow rate per cross sectional flow area. The hydraulic diameter (D_h) that was used was 5.45 mm.

Fanning friction factor measurements that correspond to the heat transfer measurements are tabulated in Appendix C2, C3, and C4 for R1234yf, R134a, and R450A, respectively. The column entitled, "flow," provides a "C" or a "P" to indicate that the measurements were made for either counterflow or parallel flow between the refrigerant and water, respectively. All the parameters given in Appendix C tables are defined in the Nomenclature.

Choi et al. (2001) present the following two-phase friction factor correlation for the micro-fin tube as:

$$f_p = 0.00506\,\mathrm{Re}^{-0.0951}\,\mathrm{K}_f^{0.1554} \tag{C2}$$

The predicted friction factor (f_p) is based on the all liquid Reynolds number (Re), and the two-phase number as defined (K_f) by Pierre (1964)

$$\mathrm{K}_f = \frac{\Delta x_q i_{fg}}{g\Delta L} \tag{C3}$$

Here, the quality change from the inlet to the exit of the increment is Δx_q, and the acceleration of gravity constant is g.

Figure C1 shows a comparison between the measured Fanning friction factors for the micro-fin tube to those predicted with the Choi et al. (2001) correlation for the R1234yf, R134a, and R450A test refrigerants. Only measurements with an uncertainty less than 40 % as given in the last column of the Appendix A tables were used in the comparison. The solid line shows the eq. (C2) prediction. The dashed lines represent predictions that are ± 20 % of the measured friction factors. The comparison shows that approximately 92 % of the measurements are overpredicted by more than 20 %.

Because of the relatively poor prediction capabilities of eq. (C2) a new correlation was developed for the prediction of the Fanning friction factor for the micro-fin tube:

$$f_p = 0.0337\,\mathrm{Re}^{0.24-0.63x_q}\;\mathrm{Bo}^{0.46-0.82x_q+0.19x_q^2} \tag{C4}$$

Figure C2 compared the measured Fanning friction factors to predictions using eq. (C4). The gray dashed lines of Fig. C2 are multi-use 95 % confidence intervals on the mean prediction, which vary from ± 17 % of the prediction at a *f* of approximately 0.0035 to approximately ± 3 % for friction factors around 0.0085. Equation (C4) predicts approximately 76 % of the measured two-phase friction factors for R1234yf, R134a, and R450A in the micro-fin tube to within approximately ± 20 %.

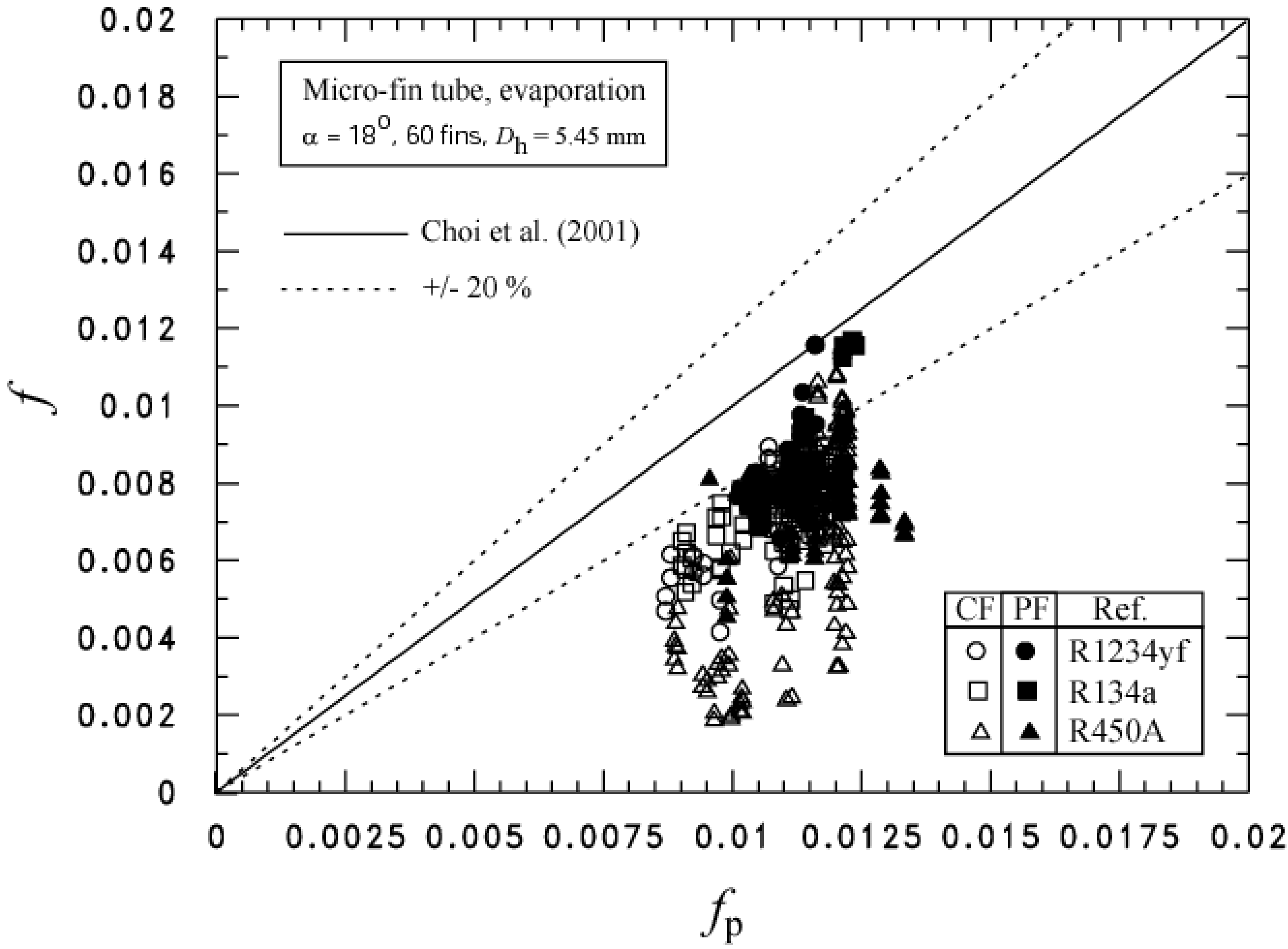

Figure C1 Comparison between measured Fanning friction factors and those predicted by Choi et al. (2001)

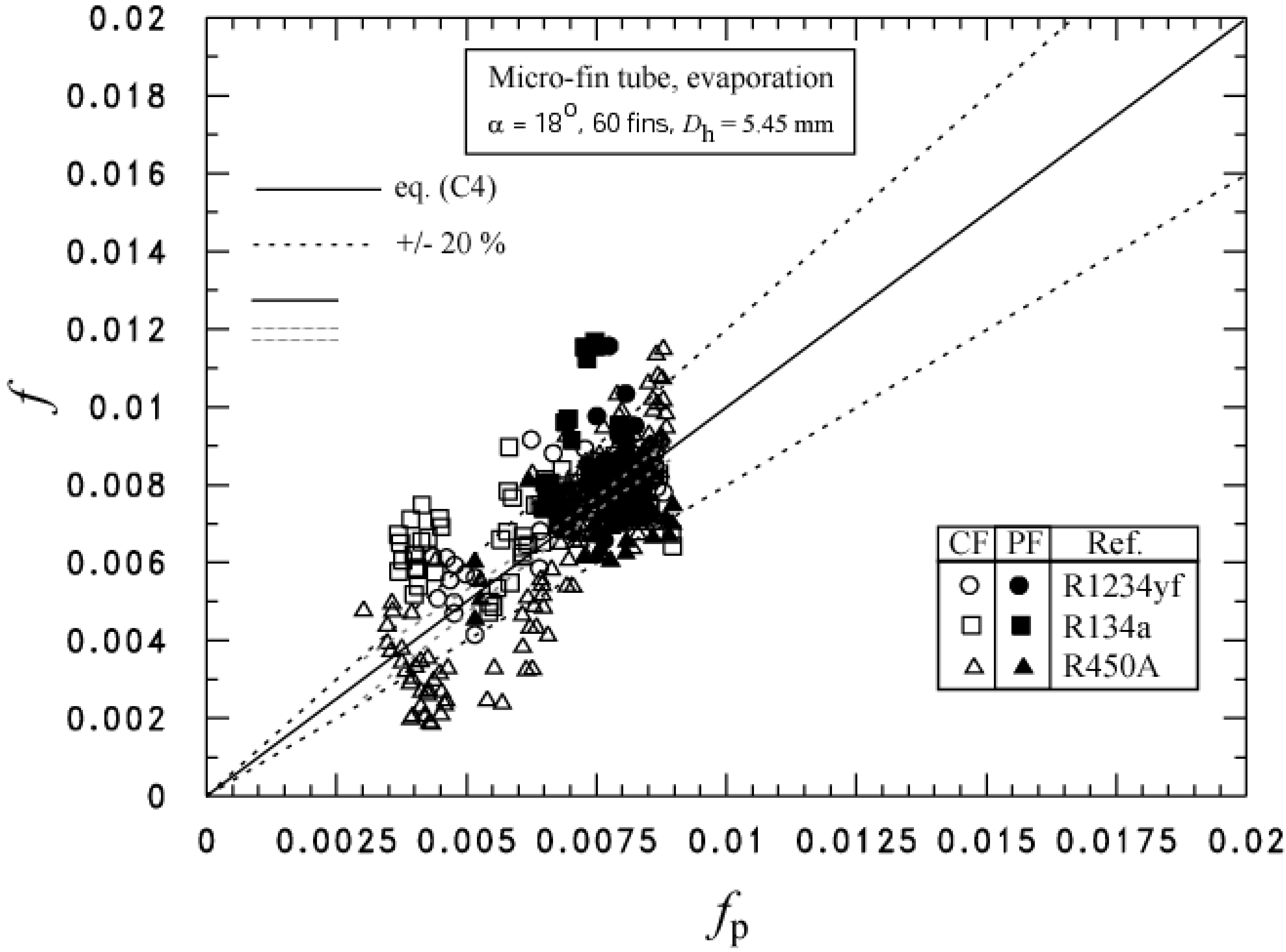

Figure C2 Comparison between measured Fanning friction factors and those predicted by eq. (C3)

APPENDIX C2

Convective boiling Fanning friction factor for R1234yf within a micro-fin tube
(file: FricGWP3b.dat)

f	z (m)	P_s (kPa)	v (m^3 kg^{-1})	x_q	Re	q'' (W m^{-2})	K_f	flow
0.0332408	0.353	370.9263	0.00119	0.007	6240	722	11625	C
0.0217052	0.967	370.4265	0.00182	0.02	6237	1363	11619	C
0.0137914	1.535	369.9689	0.00276	0.04	6234	1955	11611	C
0.0088482	2.058	369.5516	0.0039	0.064	6232	2500	11603	C
0.0059331	2.663	369.0737	0.00558	0.099	6229	3130	11591	C
0.0056124	2.998	368.8114	0.00667	0.121	6227	3479	11584	C
0.0070798	3.685	365.1899	0.01009	0.191	6204	6459	33316	C
0.0077879	4.025	364.5458	0.01245	0.239	6200	7476	33292	C
0.0085603	4.608	362.9458	0.01736	0.339	6190	9217	33247	C
0.0087779	5.152	360.8884	0.02292	0.451	6177	10840	33199	C
0.0084907	5.716	358.1801	0.02975	0.586	6160	12519	33144	C
0.0075705	6.337	354.5205	0.03855	0.757	6136	14365	33077	C
0.0239712	0.353	366.2765	0.00122	0.007	7947	794	8621	C
0.0169104	0.967	365.6684	0.00176	0.019	7942	1402	8617	C
0.0118779	1.535	365.0874	0.00251	0.034	7938	1964	8611	C
0.0085185	2.058	364.5369	0.00343	0.053	7933	2481	8604	C
0.0061564	2.663	363.8814	0.00475	0.08	7928	3079	8595	C
0.0055518	2.998	363.5099	0.0056	0.098	7925	3409	8589	C
0.0068173	3.685	358.7183	0.00839	0.153	7886	6602	30081	C
0.0076848	4.025	357.8617	0.01034	0.192	7879	7776	30059	C
0.0086421	4.608	355.6672	0.01449	0.275	7861	9788	30016	C
0.0089314	5.152	352.7925	0.01931	0.369	7838	11662	29971	C
0.0086155	5.716	348.9693	0.02531	0.483	7806	13602	29918	C
0.0075427	6.337	343.7672	0.03319	0.63	7763	15734	29854	C
0.0774719	0.353	365.4013	0.00086	0	4643	523	12822	C
0.0692278	0.967	365.0045	0.00087	0	4735	1047	12816	C
0.0615731	1.535	364.675	0.00087	0	4877	1531	12809	C
0.0545008	2.058	364.4037	0.00088	0	5059	1977	12801	C
0.046291	2.663	364.1281	0.00089	0	5335	2492	12790	C
0.0417317	2.998	363.9932	0.0009	0	5521	2777	12783	C
0.1035821	3.685	361.7505	0.00092	0	6050	4393	32853	C
0.1313429	4.025	361.3701	0.00094	0	6430	5136	32833	C
0.1744117	4.608	360.4937	0.00098	0	7295	6409	32795	C
0.2094349	5.152	359.4207	0.00103	0	8419	7596	32755	C
0.2404816	5.716	358.048	0.02885	0.568	4565	8824	32708	C
0.2684672	6.337	356.2301	0.03703	0.73	4557	10175	32650	C
0.0835175	0.353	366.9035	0.0012	0.007	3230	344	13733	C
0.0509618	0.967	366.5434	0.00184	0.02	3229	737	13726	C

0.0284681	1.535	366.271	0.00283	0.041	3228	1101	13720	C
0.0142352	2.058	366.0719	0.00409	0.067	3227	1435	13713	C
0.0055195	2.663	365.9034	0.00596	0.106	3227	1822	13703	C
0.0042689	2.998	365.8386	0.00718	0.131	3226	2036	13698	C
0.0088346	3.685	364.5052	0.01027	0.194	3222	2731	27110	C
0.0088106	4.025	364.3107	0.01218	0.234	3221	3161	27098	C
0.0086299	4.608	363.8937	0.01611	0.314	3220	3898	27073	C
0.0083024	5.152	363.4093	0.02052	0.405	3218	4585	27047	C
0.007801	5.716	362.8101	0.02588	0.514	3216	5296	27017	C
0.0070583	6.337	362.0359	0.03268	0.652	3214	6078	26981	C
0.0088624	0.353	367.3288	0.00548	0.096	6477	12823	33294	P
0.0079456	0.967	366.0209	0.0124	0.239	6468	10911	33325	P
0.0075348	1.535	364.4124	0.01788	0.351	6458	9140	33357	P
0.0075282	2.058	362.5926	0.02215	0.437	6446	7507	33388	P
0.0079652	2.663	360.0822	0.02614	0.516	6429	5617	33427	P
0.0084123	2.998	358.5053	0.02793	0.55	6419	4569	33450	P
0.0080119	3.685	343.3369	0.03402	0.645	6317	8659	28893	P
0.007636	4.025	341.2667	0.03705	0.7	6303	7740	28914	P
0.0071426	4.608	337.6226	0.04162	0.78	6279	6163	28949	P
0.0068541	5.152	334.1149	0.04513	0.839	6255	4689	28979	P
0.0067304	5.716	330.3687	0.04801	0.883	6229	3160	29009	P
0.0068006	6.337	326.1149	0.0502	0.912	6200	1474	29040	P
0.0082628	0.353	365.9123	0.00465	0.079	8242	13131	26703	P
0.0075164	0.967	364.2327	0.01026	0.194	8228	11176	26725	P
0.0071995	1.535	362.1643	0.01472	0.284	8211	9366	26749	P
0.0072253	2.058	359.8223	0.01823	0.354	8191	7698	26774	P
0.007635	2.663	356.59	0.02155	0.418	8163	5767	26805	P
0.008037	2.998	354.5588	0.02305	0.446	8146	4696	26825	P
0.0076384	3.685	333.4795	0.02909	0.534	7965	9971	23953	P
0.0075439	4.025	330.6423	0.032	0.584	7940	9000	23971	P
0.0074692	4.608	325.3465	0.03655	0.658	7893	7333	24002	P
0.0074988	5.152	319.9145	0.04025	0.715	7845	5776	24030	P
0.0076309	5.716	313.7826	0.04353	0.76	7790	4160	24059	P
0.0078956	6.337	306.4421	0.04649	0.794	7724	2379	24091	P
0.0097606	0.353	352.5037	0.00588	0.1	4895	9306	32236	P
0.0092666	0.967	351.6459	0.01262	0.234	4890	7885	32270	P
0.0091877	1.535	350.5404	0.01792	0.339	4885	6569	32302	P
0.0094364	2.058	349.2574	0.02201	0.419	4878	5356	32330	P
0.0101084	2.663	347.4561	0.02578	0.491	4869	3951	32362	P
0.0106579	2.998	346.3124	0.02743	0.521	4863	3173	32380	P
0.0080103	3.685	337.7579	0.03222	0.6	4818	5586	17131	P
0.0075742	4.025	336.6234	0.03477	0.647	4812	5168	17140	P
0.0069548	4.608	334.66	0.03872	0.718	4802	4451	17157	P
0.0065233	5.152	332.8073	0.04196	0.776	4792	3781	17171	P
0.006225	5.716	330.8655	0.04484	0.825	4782	3085	17186	P

0.0060724	6.337	328.7027	0.04745	0.868	4771	2319	17201	P
0.0160299	0.353	365.3687	0.00521	0.09	3432	6320	33750	P
0.011385	0.967	364.8691	0.01157	0.221	3431	5290	33778	P
0.0085468	1.535	364.3737	0.01647	0.322	3429	4337	33804	P
0.007173	2.058	363.8893	0.02014	0.397	3427	3459	33828	P
0.0070666	2.663	363.2952	0.02337	0.463	3425	2442	33856	P
0.0076918	2.998	362.9506	0.02469	0.49	3424	1879	33871	P
0.0101496	3.685	359.1628	0.0287	0.566	3411	4046	30468	P
0.0093398	4.025	358.5631	0.03109	0.614	3409	3531	30482	P
0.0082026	4.608	357.5677	0.03445	0.68	3405	2649	30504	P
0.0074278	5.152	356.6766	0.03677	0.725	3402	1824	30523	P
0.0069163	5.716	355.7912	0.03831	0.755	3399	969	30541	P
0.0066968	6.337	354.8614	0.03899	0.766	3396	27	30559	P
0.0277405	0.353	365.5294	0.00125	0.008	6222	799	10208	C
0.0187879	0.967	365.0773	0.00191	0.022	6219	1363	10202	C
0.0125725	1.535	364.6501	0.00283	0.041	6216	1884	10196	C
0.0086059	2.058	364.249	0.00394	0.064	6214	2364	10188	C
0.006118	2.663	363.7759	0.00553	0.096	6211	2918	10178	C
0.0057096	2.998	363.5096	0.00656	0.117	6209	3225	10172	C
0.0077051	3.685	359.8872	0.00967	0.18	6186	5802	35393	C
0.0082696	4.025	359.2349	0.01186	0.224	6182	6885	35369	C
0.0088274	4.608	357.6503	0.0165	0.317	6172	8739	35322	C
0.0088808	5.152	355.6408	0.02188	0.424	6159	10468	35272	C
0.0084601	5.716	353.0161	0.02858	0.554	6142	12257	35214	C
0.0074361	6.337	349.4888	0.03732	0.722	6120	14223	35141	C
0.0200543	0.353	359.6693	0.00125	0.008	8079	1024	8104	C
0.0139646	0.967	359.0949	0.00189	0.021	8074	1609	8099	C
0.0096903	1.535	358.5442	0.00272	0.038	8069	2150	8093	C
0.0069098	2.058	358.0208	0.0037	0.058	8065	2647	8087	C
0.0050749	2.663	357.3958	0.00508	0.086	8060	3222	8078	C
0.0046964	2.998	357.0406	0.00597	0.103	8057	3540	8072	C
0.0058501	3.685	352.4809	0.00874	0.157	8019	6579	33858	C
0.0067631	4.025	351.6555	0.01069	0.196	8012	7932	33833	C
0.0077833	4.608	349.4946	0.01496	0.279	7994	10249	33783	C
0.008114	5.152	346.6287	0.01999	0.376	7969	12408	33731	C
0.0078235	5.716	342.7915	0.02637	0.496	7937	14643	33669	C
0.006758	6.337	337.5467	0.03483	0.65	7892	17098	33593	C
0.041883	0.353	363.5682	0.00125	0.008	4755	648	12226	C
0.0267562	0.967	363.1323	0.00198	0.023	4753	1166	12220	C
0.0161904	1.535	362.7734	0.00302	0.044	4751	1644	12212	C
0.0093749	2.058	362.4806	0.00428	0.07	4749	2084	12204	C
0.0049752	2.663	362.1869	0.00612	0.108	4748	2592	12193	C
0.0041467	2.998	362.045	0.00731	0.132	4747	2874	12186	C
0.0078189	3.685	359.7316	0.01077	0.202	4736	4882	32786	C
0.008287	4.025	359.3058	0.01312	0.25	4734	5650	32765	C

0.008751	4.608	358.3009	0.01797	0.347	4729	6966	32725	C
0.0087979	5.152	357.0503	0.02345	0.457	4723	8192	32682	C
0.0084531	5.716	355.4347	0.03012	0.589	4715	9461	32632	C
0.0076102	6.337	353.2801	0.03865	0.757	4705	10856	32571	C
0.0103383	0.353	363.6106	0.00567	0.099	5846	12169	36668	P
0.0084886	0.967	362.3941	0.01294	0.248	5839	10260	36714	P
0.0074762	1.535	361.001	0.01863	0.363	5830	8493	36755	P
0.007138	2.058	359.4908	0.02299	0.451	5821	6863	36793	P
0.007457	2.663	357.4718	0.02697	0.529	5809	4976	36836	P
0.0079614	2.998	356.2283	0.02867	0.561	5802	3930	36860	P
0.0068612	3.685	345.2421	0.03378	0.644	5735	6675	28182	P
0.0065767	4.025	343.8065	0.03629	0.69	5726	5863	28201	P
0.0062133	4.608	341.3054	0.03992	0.756	5711	4469	28229	P
0.0060159	5.152	338.9264	0.04256	0.801	5696	3168	28253	P
0.0059557	5.716	336.414	0.0445	0.832	5681	1817	28275	P
0.0060596	6.337	333.5936	0.04567	0.848	5663	328	28296	P
0.0078062	0.353	356.6032	0.00481	0.08	7771	12818	26682	P
0.0073493	0.967	355.0598	0.0107	0.198	7758	10959	26704	P
0.0072184	1.535	353.1066	0.0154	0.291	7742	9238	26728	P
0.0073458	2.058	350.8617	0.01912	0.363	7724	7651	26753	P
0.00779	2.663	347.7307	0.02267	0.43	7699	5814	26786	P
0.0081728	2.998	345.7506	0.0243	0.459	7683	4796	26806	P
0.0075289	3.685	326.1184	0.03066	0.551	7520	10004	25980	P
0.0074319	4.025	323.4411	0.03376	0.604	7497	9001	26000	P
0.007358	4.608	318.4471	0.03857	0.681	7455	7281	26035	P
0.0073941	5.152	313.3277	0.04245	0.739	7411	5673	26067	P
0.0075389	5.716	307.5517	0.04583	0.785	7362	4004	26099	P
0.0078244	6.337	300.6404	0.04882	0.819	7302	2164	26134	P
0.0115684	0.353	363.0959	0.00579	0.101	4419	9400	35541	P
0.0095171	0.967	362.322	0.01323	0.254	4416	8001	35575	P
0.0083868	1.535	361.4241	0.01909	0.373	4411	6706	35607	P
0.007998	2.058	360.4427	0.02361	0.465	4407	5512	35638	P
0.0083282	2.663	359.1224	0.02782	0.548	4401	4129	35675	P
0.0088709	2.998	358.306	0.02965	0.584	4397	3363	35696	P
0.0091783	3.685	350.4681	0.03524	0.682	4362	6300	35125	P
0.0084089	4.025	349.351	0.03825	0.74	4356	5534	35146	P
0.0073195	4.608	347.504	0.04257	0.821	4348	4221	35180	P
0.0065649	5.152	345.8584	0.04564	0.877	4340	2994	35209	P
0.0060496	5.716	344.2318	0.04779	0.916	4333	1721	35236	P
0.0057966	6.337	342.5343	0.04899	0.934	4325	318	35263	P
0.0154585	0.353	364.8424	0.00575	0.101	3376	7050	37141	P
0.0111126	0.967	364.3136	0.01299	0.25	3374	5936	37174	P
0.0084726	1.535	363.7787	0.01859	0.365	3372	4903	37204	P
0.0072149	2.058	363.2474	0.02284	0.452	3370	3952	37232	P
0.007163	2.663	362.5864	0.02664	0.529	3368	2851	37264	P

0.0077817	2.998	362.1989	0.02822	0.561	3367	2241	37282	P
0.0091898	3.685	357.8925	0.03295	0.651	3352	4583	34939	P
0.0084237	4.025	357.2854	0.03572	0.705	3350	3985	35865	P
0.0073427	4.608	356.2853	0.03957	0.781	3346	2957	36545	P
0.0065992	5.152	355.3987	0.04217	0.832	3343	1997	36147	P
0.0060985	5.716	354.5268	0.04386	0.863	3340	1002	34680	P
0.0058654	6.337	353.6227	0.04454	0.875	3337	0	31824	P
0.0956125	0.353	366.8834	0.00086	0	3449	220	13628	C
0.0556388	0.967	366.5121	0.00157	0.015	3424	634	13622	C
0.0292053	1.535	366.2362	0.00242	0.032	3423	1017	13616	C
0.0138284	2.058	366.0397	0.00354	0.055	3422	1369	13609	C
0.0067599	2.663	365.8812	0.00524	0.091	3422	1776	13600	C
0.0077921	2.998	365.8251	0.00636	0.114	3421	2002	13595	C
0.0092122	3.685	364.5008	0.00912	0.171	3417	2514	28128	C
0.0091617	4.025	364.3002	0.0108	0.205	3416	2987	28115	C
0.0089215	4.608	363.8682	0.01436	0.278	3415	3798	28091	C
0.0085228	5.152	363.3649	0.01847	0.362	3413	4553	28065	C
0.0079312	5.716	362.7408	0.02351	0.465	3411	5336	28034	C
0.0070701	6.337	361.9334	0.03002	0.598	3408	6197	27997	C

APPENDIX C3

Convective boiling Fanning friction factor of R134a within a micro-fin tube
(file: FricGWP3b.dat)

f	z (m)	P_s (kPa)	v (m^3 kg^{-1})	x_q	Re	q'' (W m^{-2})	K_f	flow
0.0401405	0.353	352.4095	0.00102	0.004	4663	618	12186	C
0.0252471	0.967	351.9432	0.00162	0.015	4660	1256	12180	C
0.01519	1.535	351.5258	0.00252	0.03	4658	1845	12172	C
0.0090917	2.058	351.1532	0.00366	0.05	4657	2387	12164	C
0.0058192	2.663	350.7364	0.00533	0.079	4655	3013	12153	C
0.0057521	2.998	350.5121	0.00642	0.098	4653	3360	12146	C
0.0054804	3.685	347.6174	0.00962	0.153	4639	5662	32939	C
0.0065296	4.025	347.1579	0.01178	0.19	4637	6616	32918	C
0.0077707	4.608	345.9391	0.01631	0.267	4631	8250	32877	C
0.0082933	5.152	344.3109	0.02147	0.354	4623	9772	32835	C
0.0081872	5.716	342.1226	0.02784	0.46	4613	11349	32785	C
0.0073074	6.337	339.1239	0.03606	0.594	4598	13081	32725	C
0.0305719	0.353	351.1454	0.00083	0.001	6533	587	9497	C
0.0207766	0.967	350.5706	0.00126	0.008	6529	1284	9492	C
0.0139416	1.535	350.006	0.00194	0.02	6525	1928	9486	C
0.0095404	2.058	349.4583	0.0028	0.035	6521	2521	9480	C
0.0067122	2.663	348.7914	0.00409	0.057	6517	3206	9470	C
0.0061905	2.998	348.4068	0.00493	0.072	6514	3585	9464	C
0.0048713	3.685	343.794	0.00765	0.117	6483	6739	28281	C
0.0062436	4.025	343.1021	0.00951	0.149	6478	7888	28261	C
0.0078826	4.608	341.12	0.01346	0.215	6464	9856	28222	C
0.0085985	5.152	338.3639	0.01801	0.29	6445	11689	28182	C
0.0085114	5.716	334.5823	0.02368	0.381	6419	13587	28136	C
0.0074391	6.337	329.3304	0.03113	0.497	6383	15673	28080	C
0.0378321	0.353	349.0651	0.00118	0.007	4443	733	11962	C
0.0250017	0.967	348.5898	0.00187	0.019	4441	1331	11955	C
0.0162036	1.535	348.1432	0.00286	0.036	4439	1884	11948	C
0.0107124	2.058	347.7259	0.00407	0.057	4437	2393	11940	C
0.0074819	2.663	347.2362	0.00583	0.087	4435	2981	11928	C
0.0071334	2.998	346.9617	0.00697	0.107	4433	3306	11921	C
0.0066718	3.685	343.7099	0.01045	0.165	4418	5951	33816	C
0.0074458	4.025	343.1866	0.01284	0.206	4416	6887	33793	C
0.0083162	4.608	341.8767	0.01779	0.289	4410	8491	33750	C
0.008608	5.152	340.184	0.02339	0.382	4402	9985	33704	C
0.0083801	5.716	337.9497	0.03025	0.495	4391	11532	33651	C
0.0075045	6.337	334.9251	0.03907	0.637	4377	13233	33586	C
0.0252934	0.353	353.5625	0.00108	0.005	6116	602	9832	C
0.0176721	0.967	353.0367	0.00154	0.013	6112	1276	9828	C

0.0122391	1.535	352.5292	0.00225	0.026	6109	1899	9822	C
0.008611	2.058	352.0439	0.00315	0.041	6106	2472	9815	C
0.006058	2.663	351.4611	0.00448	0.065	6103	3134	9805	C
0.0054029	2.998	351.1286	0.00535	0.08	6100	3501	9799	C
0.005347	3.685	346.7581	0.00813	0.127	6073	6497	30472	C
0.0064702	4.025	346.0914	0.01005	0.159	6068	7653	30451	C
0.007785	4.608	344.2767	0.01411	0.228	6057	9633	30411	C
0.0083155	5.152	341.8182	0.01882	0.306	6041	11478	30369	C
0.0081556	5.716	338.4895	0.02469	0.402	6020	13388	30320	C
0.0071438	6.337	333.9059	0.03238	0.524	5990	15487	30261	C
0.0680141	0.353	350.6219	0.00078	0	3773	482	14141	C
0.0407578	0.967	350.1757	0.00079	0	3846	1077	14135	C
0.022582	1.535	349.7939	0.00264	0.032	3742	1627	14127	C
0.011828	2.058	349.4685	0.00389	0.054	3741	2134	14118	C
0.0065424	2.663	349.1235	0.00576	0.086	3739	2719	14106	C
0.006917	2.998	348.947	0.00699	0.108	3739	3043	14099	C
0.0076713	3.685	346.3396	0.01046	0.166	3728	4817	34067	C
0.0081351	4.025	345.9369	0.01274	0.205	3727	5611	34047	C
0.00859	4.608	344.9841	0.01749	0.286	3723	6971	34008	C
0.0086267	5.152	343.7962	0.02289	0.377	3718	8238	33967	C
0.0082694	5.716	342.2601	0.02948	0.488	3712	9551	33920	C
0.0074106	6.337	340.21	0.03796	0.628	3704	10993	33862	C
0.0786408	0.353	344.3439	0.00114	0.006	2600	358	14153	C
0.0481941	0.967	343.995	0.00179	0.017	2599	774	14147	C
0.0271931	1.535	343.7254	0.00281	0.035	2598	1158	14140	C
0.0139451	2.058	343.5224	0.0041	0.057	2597	1513	14133	C
0.0059026	2.663	343.3418	0.00601	0.089	2597	1922	14123	C
0.0048099	2.998	343.2667	0.00727	0.111	2597	2149	14117	C
0.0092855	3.685	341.6416	0.01041	0.163	2592	2797	28353	C
0.0089687	4.025	341.4281	0.01232	0.196	2592	3259	28340	C
0.008391	4.608	340.9873	0.01629	0.263	2590	4050	28315	C
0.0078127	5.152	340.4909	0.02078	0.338	2589	4787	28289	C
0.007173	5.716	339.8895	0.02622	0.43	2587	5551	28258	C
0.0064215	6.337	339.1253	0.03319	0.546	2585	6391	28220	C
0.0091453	0.353	354.3932	0.00531	0.08	4487	11850	32456	P
0.0081701	0.967	353.3653	0.01246	0.205	4482	10219	32485	P
0.0077123	1.535	352.0856	0.01819	0.304	4476	8709	32514	P
0.0076683	2.058	350.6278	0.02273	0.382	4470	7317	32543	P
0.0080691	2.663	348.607	0.02709	0.455	4460	5706	32578	P
0.0084994	2.998	347.3339	0.02909	0.488	4454	4813	32599	P
0.0081216	3.685	334.4481	0.03532	0.574	4394	8005	29620	P
0.0078829	4.025	332.7744	0.03839	0.622	4386	7180	29640	P
0.0076025	4.608	329.7612	0.04301	0.692	4371	5766	29672	P
0.0074879	5.152	326.7861	0.04657	0.744	4357	4445	29700	P
0.0075189	5.716	323.5352	0.04948	0.784	4342	3074	29728	P

0.0077295	6.337	319.7597	0.05177	0.811	4323	1563	29756	P
0.0112347	0.353	352.2064	0.00646	0.099	3457	10912	40675	P
0.0092451	0.967	351.3733	0.01499	0.248	3454	9334	40715	P
0.008144	1.535	350.4035	0.02173	0.365	3451	7872	40754	P
0.0077585	2.058	349.3412	0.02698	0.455	3447	6525	40790	P
0.008064	2.663	347.91	0.03191	0.538	3442	4965	40834	P
0.00858	2.998	347.0242	0.0341	0.574	3439	4100	40858	P
0.0080152	3.685	339.1545	0.04025	0.665	3410	6665	37458	P
0.0073756	4.025	338.0692	0.0434	0.716	3406	5860	37481	P
0.0064656	4.608	336.2758	0.04795	0.788	3400	4479	37518	P
0.005829	5.152	334.6792	0.05115	0.838	3394	3189	37549	P
0.0053857	5.716	333.1023	0.05347	0.872	3388	1850	37577	P
0.0051528	6.337	331.4582	0.05472	0.889	3382	376	37605	P
0.0073857	0.353	345.3193	0.00435	0.061	6619	12555	23923	P
0.0069653	0.967	343.7846	0.00958	0.15	6608	10765	23943	P
0.0068455	1.535	341.8527	0.01378	0.221	6594	9107	23964	P
0.0069638	2.058	339.6387	0.01712	0.276	6579	7580	23985	P
0.0073741	2.663	336.5571	0.02032	0.327	6557	5811	24012	P
0.0077274	2.998	334.6105	0.0218	0.35	6544	4831	24028	P
0.007495	3.685	314.6021	0.02759	0.42	6400	9569	20794	P
0.0074077	4.025	311.8395	0.03034	0.459	6380	8708	20809	P
0.0073325	4.608	306.675	0.03467	0.517	6342	7229	20834	P
0.0073476	5.152	301.3687	0.0383	0.563	6303	5847	20858	P
0.0074499	5.716	295.3707	0.04159	0.601	6258	4414	20882	P
0.0076648	6.337	288.1817	0.04468	0.631	6204	2833	20908	P
0.01611	0.353	349.731	0.00609	0.092	2561	7547	38578	P
0.0115473	0.967	349.1871	0.01405	0.23	2560	6435	38612	P
0.0087648	1.535	348.6321	0.02031	0.338	2559	5405	38643	P
0.0074251	2.058	348.0771	0.02512	0.421	2557	4456	38672	P
0.0073375	2.663	347.3823	0.02958	0.497	2555	3358	38706	P
0.0079636	2.998	346.9733	0.03153	0.53	2554	2749	38725	P
0.0091796	3.685	342.7031	0.03684	0.614	2543	4751	36732	P
0.0085646	4.025	342.0765	0.03977	0.663	2541	4165	36750	P
0.0077172	4.608	341.0189	0.04394	0.731	2538	3159	36780	P
0.0071625	5.152	340.0511	0.04686	0.778	2536	2220	36804	P
0.006828	5.716	339.0672	0.04884	0.81	2533	1245	36827	P
0.006743	6.337	338.0068	0.04984	0.824	2530	172	36850	P
0.0096906	0.353	349.1855	0.00538	0.08	4564	11776	32548	P
0.0084675	0.967	348.0784	0.0124	0.201	4559	10103	32579	P
0.0078554	1.535	346.7277	0.01801	0.297	4553	8554	32609	P
0.0077331	2.058	345.2064	0.02242	0.371	4545	7127	32638	P
0.0081196	2.663	343.1147	0.02662	0.44	4535	5474	32675	P
0.0085772	2.998	341.8033	0.02852	0.471	4529	4557	32696	P
0.0087669	3.685	328.4198	0.03465	0.553	4464	7904	27724	P
0.0083625	4.025	326.5884	0.03769	0.599	4455	7115	27743	P

0.0078253	4.608	323.3613	0.04228	0.667	4439	5761	27773	P
0.0075021	5.152	320.2511	0.04587	0.718	4424	4496	27801	P
0.0073486	5.716	316.9258	0.04886	0.758	4408	3184	27827	P
0.0073933	6.337	313.1458	0.05125	0.786	4389	1737	27855	P
0.0095971	0.353	349.1979	0.00526	0.078	4588	11602	31856	P
0.0083916	0.967	348.1096	0.01214	0.196	4583	9956	31886	P
0.0077892	1.535	346.7818	0.01765	0.29	4577	8432	31915	P
0.0076704	2.058	345.2863	0.02197	0.363	4570	7028	31944	P
0.0080543	2.663	343.2298	0.02609	0.431	4560	5401	31979	P
0.0085074	2.998	341.9405	0.02795	0.461	4554	4500	32000	P
0.008751	3.685	328.8506	0.03395	0.542	4490	7836	27610	P
0.0083887	4.025	327.0355	0.03694	0.588	4481	7046	27628	P
0.0079191	4.608	323.8148	0.04145	0.655	4465	5691	27659	P
0.0076535	5.152	320.6862	0.04497	0.705	4450	4424	27686	P
0.0075541	5.716	317.3167	0.04789	0.744	4433	3110	27712	P
0.007652	6.337	313.4585	0.05021	0.771	4413	1662	27739	P
0.0077467	0.353	351.4178	0.00435	0.062	6692	12822	25119	P
0.0071564	0.967	349.8301	0.00957	0.153	6681	10934	25141	P
0.0069333	1.535	347.8609	0.01374	0.224	6667	9185	25163	P
0.0070022	2.058	345.6223	0.01702	0.279	6652	7574	25186	P
0.0074102	2.663	342.524	0.02015	0.329	6630	5708	25214	P
0.0077875	2.998	340.5737	0.02157	0.352	6616	4674	25230	P
0.0078345	3.685	320.185	0.02713	0.42	6471	9388	19228	P
0.0077474	4.025	317.3327	0.02981	0.458	6450	8587	19241	P
0.0076665	4.608	311.9991	0.03404	0.516	6411	7214	19264	P
0.0076692	5.152	306.5178	0.03762	0.562	6371	5930	19285	P
0.0077515	5.716	300.3206	0.04092	0.601	6325	4599	19307	P
0.0079358	6.337	292.8915	0.04412	0.633	6269	3130	19331	P
0.0080492	0.353	350.3807	0.00431	0.061	6722	12708	24605	P
0.0074317	0.967	348.7467	0.00948	0.151	6711	10848	24627	P
0.0071936	1.535	346.7126	0.01362	0.221	6697	9126	24649	P
0.0072576	2.058	344.3956	0.01688	0.275	6681	7538	24671	P
0.0076703	2.663	341.1841	0.01999	0.326	6658	5700	24698	P
0.0080551	2.998	339.1608	0.02142	0.348	6643	4682	24714	P
0.0077208	3.685	318.41	0.02702	0.416	6494	9379	19050	P
0.0076559	4.025	315.5715	0.02969	0.454	6474	8581	19063	P
0.0076071	4.608	310.2443	0.03392	0.512	6434	7213	19085	P
0.0076329	5.152	304.7492	0.03749	0.557	6394	5934	19106	P
0.0077323	5.716	298.5179	0.04083	0.596	6347	4607	19128	P
0.0079274	6.337	291.0276	0.04405	0.628	6290	3144	19152	P
0.0115285	0.353	354.3365	0.00633	0.098	3426	10715	40836	P
0.0095266	0.967	353.5187	0.01474	0.245	3423	9148	40876	P
0.0084288	1.535	352.5601	0.02139	0.361	3420	7697	40915	P
0.0080588	2.058	351.5057	0.02655	0.45	3416	6359	40951	P
0.0083974	2.663	350.0805	0.03137	0.532	3411	4811	40993	P

0.0089386	2.998	349.1965	0.0335	0.567	3408	3953	41017	P
0.0086652	3.685	340.6349	0.03958	0.657	3377	6519	33282	P
0.0080706	4.025	339.5064	0.04271	0.707	3373	5812	33302	P
0.0072344	4.608	337.602	0.04731	0.781	3366	4599	33335	P
0.0066628	5.152	335.8597	0.05075	0.834	3360	3466	33362	P
0.006283	5.716	334.0889	0.05338	0.873	3353	2290	33389	P
0.0061155	6.337	332.1809	0.05518	0.898	3347	994	33415	P
0.0158223	0.353	344.885	0.00614	0.092	2614	7694	37798	P
0.011678	0.967	344.3112	0.01416	0.229	2612	6577	37831	P
0.0091812	1.535	343.7052	0.02048	0.336	2610	5542	37862	P
0.0080187	2.058	343.0833	0.02538	0.419	2609	4588	37891	P
0.0080331	2.663	342.2875	0.02994	0.496	2607	3485	37925	P
0.0086683	2.998	341.8115	0.03194	0.529	2605	2873	37944	P
0.0091748	3.685	337.0821	0.03749	0.615	2592	4955	35931	P
0.008559	4.025	336.4107	0.04052	0.664	2590	4367	35950	P
0.0077071	4.608	335.2755	0.04487	0.735	2587	3358	35980	P
0.0071446	5.152	334.2348	0.04797	0.784	2584	2416	36005	P
0.0067983	5.716	333.1745	0.05017	0.818	2581	1438	36029	P
0.006696	6.337	332.0292	0.05143	0.836	2578	361	36052	P
0.0386506	0.353	349.2588	0.0011	0.005	4689	578	11479	C
0.0254512	0.967	348.7754	0.00166	0.015	4687	1184	11473	C
0.0163457	1.535	348.3301	0.00251	0.03	4685	1744	11467	C
0.0106007	2.058	347.9216	0.00359	0.049	4683	2259	11459	C
0.0071113	2.663	347.4509	0.00517	0.076	4680	2855	11449	C
0.0066356	2.998	347.191	0.00621	0.094	4679	3184	11442	C
0.0065916	3.685	344.0701	0.00924	0.145	4664	5392	37454	C
0.0074684	4.025	343.5591	0.01133	0.18	4661	6486	37430	C
0.008438	4.608	342.2431	0.01585	0.256	4655	8361	37385	C
0.0087345	5.152	340.5138	0.02115	0.345	4646	10108	37336	C
0.0084219	5.716	338.2101	0.02779	0.454	4635	11916	37279	C
0.0073477	6.337	335.0719	0.03651	0.595	4619	13904	37208	C
0.0268784	0.353	348.5903	0.00106	0.005	6314	638	9178	C
0.0183576	0.967	347.9996	0.00153	0.013	6310	1290	9174	C
0.0123507	1.535	347.4477	0.00223	0.025	6307	1894	9168	C
0.0084137	2.058	346.9349	0.0031	0.04	6303	2449	9161	C
0.0057659	2.663	346.3362	0.00439	0.062	6299	3090	9152	C
0.0051794	2.998	346.0021	0.00523	0.076	6297	3445	9146	C
0.0047274	3.685	341.4077	0.00787	0.12	6267	6310	33004	C
0.0061477	4.025	340.7591	0.00972	0.151	6262	7610	32981	C
0.0078307	4.608	338.8711	0.01373	0.218	6250	9835	32936	C
0.0085441	5.152	336.2253	0.01849	0.296	6232	11909	32889	C
0.0084101	5.716	332.5811	0.0245	0.392	6208	14056	32835	C
0.0072338	6.337	327.5074	0.03249	0.516	6173	16415	32768	C
0.026489	0.353	345.5839	0.00115	0.006	6329	751	8791	C
0.018512	0.967	344.9392	0.00166	0.015	6325	1379	8786	C

0.0128502	1.535	344.3254	0.0024	0.028	6321	1960	8780	C
0.0090966	2.058	343.7456	0.0033	0.043	6317	2495	8774	C
0.0065002	2.663	343.0573	0.00461	0.065	6312	3113	8765	C
0.0058682	2.998	342.6681	0.00546	0.08	6310	3454	8759	C
0.0049852	3.685	337.7479	0.00813	0.123	6277	6300	33485	C
0.0063925	4.025	337.0521	0.00998	0.154	6272	7626	33461	C
0.0080521	4.608	335.0504	0.01404	0.221	6259	9896	33416	C
0.0087422	5.152	332.2613	0.01887	0.299	6240	12012	33367	C
0.0085826	5.716	328.4306	0.025	0.395	6214	14202	33310	C
0.0073764	6.337	323.1069	0.03315	0.52	6177	16608	33240	C
0.0441949	0.353	343.3214	0.00114	0.006	3919	582	12409	C
0.0286664	0.967	342.8654	0.0018	0.017	3917	1133	12403	C
0.0178031	1.535	342.4757	0.00278	0.034	3915	1642	12396	C
0.0107766	2.058	342.1443	0.00399	0.054	3914	2110	12388	C
0.006208	2.663	341.7936	0.00576	0.085	3912	2652	12377	C
0.0053208	2.998	341.6145	0.00692	0.104	3912	2951	12371	C
0.0067876	3.685	339.0283	0.01026	0.16	3901	4913	32718	C
0.0074848	4.025	338.6246	0.01251	0.197	3899	5716	32698	C
0.0082574	4.608	337.6311	0.01719	0.275	3895	7093	32659	C
0.0084963	5.152	336.3609	0.0225	0.363	3890	8377	32618	C
0.0082528	5.716	334.6942	0.029	0.469	3883	9706	32570	C
0.0074061	6.337	332.4472	0.03737	0.604	3873	11166	32511	C
0.0773815	0.353	346.9241	0.00113	0.006	2669	352	13607	C
0.0486852	0.967	346.5739	0.00175	0.017	2668	762	13601	C
0.0287651	1.535	346.2916	0.00272	0.033	2667	1140	13595	C
0.016055	2.058	346.067	0.00395	0.055	2667	1489	13588	C
0.0080878	2.663	345.8495	0.00579	0.086	2666	1892	13579	C
0.0067842	2.998	345.7486	0.00699	0.107	2666	2115	13573	C
0.0076183	3.685	344.1441	0.01005	0.158	2661	2871	29478	C
0.007832	4.025	343.9558	0.01196	0.191	2661	3362	29465	C
0.0079742	4.608	343.5351	0.01594	0.259	2660	4204	29439	C
0.0078515	5.152	343.031	0.02046	0.335	2658	4989	29411	C
0.0074639	5.716	342.3947	0.02599	0.429	2656	5802	29378	C
0.0067305	6.337	341.5602	0.03306	0.548	2654	6696	29339	C

APPENDIX C4

Convective boiling Fanning friction factor of R450A within a micro-fin tube
(file: FricGWP3b.dat)

f	z (m)	P_s (kPa)	v (m^3 kg^{-1})	x_q	Re	q'' (W m^{-2})	K_f	flow
0.013225	0.353	312.3346	0.00088	0.001	4738	522	13649	C
0.0093077	0.967	312.168	0.0015	0.011	4737	1240	13640	C
0.0065506	1.535	311.9716	0.00251	0.028	4737	1904	13627	C
0.0047498	2.058	311.755	0.00383	0.049	4736	2515	13613	C
0.003549	2.663	311.4615	0.0058	0.081	4736	3221	13594	C
0.0032914	2.998	311.2792	0.0071	0.102	4735	3611	13581	C
0.0048687	3.685	308.5711	0.01099	0.164	4722	6483	51670	C
0.0065263	4.025	308.0421	0.01383	0.209	4721	7989	51620	C
0.0084682	4.608	306.417	0.02015	0.309	4715	10568	51530	C
0.0092542	5.152	304.0825	0.02777	0.428	4705	12969	51440	C
0.0090232	5.716	300.8281	0.0375	0.576	4692	15455	51341	C
0.0075374	6.337	296.2628	0.05052	0.77	4672	18186	51224	C
0.008672	0.353	308.0171	0.00081	0	6986	412	8781	C
0.0070986	0.967	307.8034	0.00117	0.006	6985	1097	8776	C
0.0058073	1.535	307.534	0.0018	0.016	6983	1730	8769	C
0.0047577	2.058	307.2248	0.00263	0.029	6981	2312	8760	C
0.0037105	2.663	306.7942	0.00389	0.049	6978	2985	8748	C
0.0032076	2.998	306.522	0.00472	0.062	6977	3357	8740	C
0.0023826	3.685	302.7038	0.00769	0.109	6948	7484	34126	C
0.0043285	4.025	302.1206	0.00991	0.143	6944	8958	34092	C
0.0066822	4.608	300.026	0.01475	0.218	6931	11481	34030	C
0.0077584	5.152	296.8246	0.02049	0.305	6908	13831	33967	C
0.0077326	5.716	292.2344	0.0278	0.412	6875	16263	33897	C
0.0063597	6.337	285.6835	0.03762	0.55	6826	18935	33814	C
0.0180751	0.353	308.4148	0.00103	0.004	3760	411	14008	C
0.0113648	0.967	308.2667	0.00166	0.014	3760	999	13999	C
0.0068445	1.535	308.1213	0.0027	0.03	3759	1542	13987	C
0.0041161	2.058	307.9804	0.00404	0.052	3759	2042	13973	C
0.0026749	2.663	307.8089	0.00607	0.084	3759	2619	13954	C
0.0026682	2.998	307.71	0.0074	0.106	3759	2939	13941	C
0.0048442	3.685	305.6537	0.01178	0.175	3752	5948	40467	C
0.0069402	4.025	305.2791	0.01495	0.225	3751	6888	40427	C
0.0095046	4.608	304.088	0.02154	0.329	3749	8498	40355	C
0.0107245	5.152	302.3514	0.02902	0.445	3744	9997	40283	C
0.0107936	5.716	299.9137	0.03823	0.586	3736	11548	40202	C
0.0094618	6.337	296.4793	0.05016	0.765	3725	13253	40107	C
0.0250978	0.353	308.2316	0.00109	0.005	2104	292	14885	C
0.010939	0.967	308.1736	0.00182	0.016	2104	642	14875	C
0.0048123	1.535	308.1305	0.00299	0.035	2104	965	14864	C

0.005096	2.058	308.0998	0.00448	0.059	2104	1262	14852	C
0.0125105	2.663	308.075	0.00669	0.094	2105	1606	14836	C
0.0198859	2.998	308.0662	0.00815	0.118	2105	1796	14826	C
0.0129102	3.685	307.0189	0.01256	0.188	2103	3221	27787	C
0.0139034	4.025	306.7769	0.01554	0.236	2103	3582	27765	C
0.0150148	4.608	306.188	0.02142	0.329	2103	4201	27726	C
0.0153779	5.152	305.4404	0.02778	0.43	2103	4778	27685	C
0.0150672	5.716	304.4633	0.0353	0.548	2102	5375	27640	C
0.013916	6.337	303.1498	0.04466	0.695	2101	6031	27586	C
0.0118587	0.353	307.1786	0.001	0.003	4842	510	12631	C
0.0085801	0.967	307.0054	0.00159	0.013	4841	1193	12622	C
0.0062225	1.535	306.8046	0.00255	0.028	4840	1825	12611	C
0.0046256	2.058	306.5853	0.0038	0.048	4840	2406	12598	C
0.0034649	2.663	306.2903	0.00566	0.077	4839	3078	12579	C
0.0031389	2.998	306.108	0.00689	0.097	4839	3449	12567	C
0.0051577	3.685	303.2392	0.01098	0.161	4824	7215	47446	C
0.0066922	4.025	302.6473	0.01406	0.209	4822	8636	47398	C
0.0084846	4.608	300.8697	0.0207	0.312	4815	11070	47310	C
0.0092013	5.152	298.3421	0.02852	0.432	4805	13336	47222	C
0.0089703	5.716	294.8359	0.03842	0.579	4789	15682	47125	C
0.0075687	6.337	289.9324	0.0515	0.769	4767	18258	47011	C
0.0108959	0.353	308.2415	0.00085	0.001	6915	431	8323	C
0.0084359	0.967	307.9831	0.00122	0.007	6913	1073	8318	C
0.0065512	1.535	307.6842	0.00184	0.017	6911	1667	8311	C
0.005148	2.058	307.3579	0.00264	0.029	6909	2213	8303	C
0.0039221	2.663	306.9196	0.00386	0.049	6907	2845	8291	C
0.0034267	2.998	306.6488	0.00466	0.062	6905	3194	8283	C
0.0032878	3.685	302.6462	0.0075	0.106	6875	6995	32356	C
0.0050904	4.025	302.0075	0.00961	0.138	6871	8377	32324	C
0.0072486	4.608	299.8767	0.01419	0.209	6857	10745	32265	C
0.0081997	5.152	296.7085	0.01963	0.291	6835	12950	32205	C
0.0081025	5.716	292.2212	0.02655	0.393	6802	15231	32138	C
0.0067199	6.337	285.8642	0.03585	0.523	6756	17738	32059	C
0.008019	0.353	308.8839	0.00102	0.004	3796	449	13626	C
0.0057478	0.967	308.803	0.00166	0.014	3796	1025	13617	C
0.0041295	1.535	308.7059	0.00271	0.031	3796	1559	13605	C
0.0030497	2.058	308.5975	0.00405	0.052	3796	2049	13592	C
0.0022914	2.663	308.4494	0.00605	0.084	3796	2616	13573	C
0.002098	2.998	308.357	0.00737	0.105	3796	2930	13561	C
0.0055688	3.685	306.2584	0.01164	0.173	3789	5883	43084	C
0.0072583	4.025	305.8554	0.01477	0.222	3788	6893	43043	C
0.0092802	4.608	304.6558	0.02134	0.326	3785	8622	42967	C
0.0101697	5.152	302.9571	0.02888	0.444	3781	10233	42890	C
0.0100755	5.716	300.6053	0.03823	0.587	3774	11900	42805	C
0.008775	6.337	297.3203	0.05035	0.771	3763	13731	42703	C

0.0109534	0.353	309.2497	0.00098	0.003	3801	446	14201	C
0.0067231	0.967	309.1538	0.00163	0.013	3801	1048	14191	C
0.0040107	1.535	309.0524	0.0027	0.03	3801	1604	14179	C
0.0025337	2.058	308.9484	0.00408	0.053	3801	2116	14165	C
0.0020459	2.663	308.8154	0.00614	0.086	3801	2707	14145	C
0.002339	2.998	308.7358	0.0075	0.108	3801	3034	14133	C
0.0041184	3.685	306.8949	0.01193	0.178	3795	6149	44637	C
0.0061593	4.025	306.5447	0.01518	0.23	3795	7196	44594	C
0.008654	4.608	305.4008	0.022	0.338	3792	8990	44515	C
0.009837	5.152	303.7145	0.02984	0.46	3788	10660	44435	C
0.0098965	5.716	301.3354	0.03953	0.609	3781	12389	44346	C
0.008588	6.337	297.9728	0.05215	0.8	3770	14288	44241	C
0.0118436	0.353	308.1321	0.00097	0.003	3908	458	14212	C
0.0071059	0.967	308.0255	0.00162	0.013	3908	1078	14202	C
0.0040988	1.535	307.9156	0.00269	0.03	3908	1651	14190	C
0.0024992	2.058	307.8048	0.00407	0.052	3908	2178	14175	C
0.0020471	2.663	307.6653	0.00615	0.086	3908	2787	14154	C
0.002442	2.998	307.5827	0.00751	0.107	3908	3124	14141	C
0.005824	3.685	305.1381	0.01204	0.179	3899	6445	46134	C
0.007202	4.025	304.6852	0.01537	0.231	3898	7560	46088	C
0.008817	4.608	303.3878	0.02241	0.342	3895	9468	46004	C
0.009472	5.152	301.5839	0.03049	0.467	3890	11245	45919	C
0.0092826	5.716	299.109	0.0405	0.62	3882	13084	45826	C
0.0080515	6.337	295.6717	0.05353	0.816	3871	15104	45716	C
0.0241025	0.353	310.0617	0.0008	0	2108	165	14238	C
0.0160482	0.967	310.0136	0.00131	0.008	2109	500	14229	C
0.0105078	1.535	309.9609	0.00226	0.023	2109	809	14218	C
0.00703	2.058	309.9056	0.00352	0.044	2109	1093	14208	C
0.0049489	2.663	309.8335	0.00546	0.075	2109	1422	14193	C
0.0046925	2.998	309.7898	0.00675	0.096	2109	1604	14185	C
0.0139388	3.685	308.7956	0.01048	0.156	2108	2669	26716	C
0.0149473	4.025	308.58	0.01295	0.195	2108	3016	26697	C
0.0160355	4.608	308.0549	0.01793	0.275	2108	3612	26661	C
0.0163206	5.152	307.3878	0.02341	0.362	2107	4166	26625	C
0.0158717	5.716	306.5156	0.02994	0.466	2106	4741	26584	C
0.0145009	6.337	305.3428	0.03818	0.596	2105	5372	26536	C
0.0074897	0.353	308.0464	0.00741	0.106	4840	15825	48882	P
0.0071667	0.967	306.5649	0.01743	0.266	4837	13182	48963	P
0.0071693	1.535	304.664	0.02522	0.388	4830	10733	49040	P
0.0074276	2.058	302.463	0.03114	0.479	4820	8475	49112	P
0.0080328	2.663	299.3778	0.03649	0.558	4805	5859	49197	P
0.0085091	2.998	297.4207	0.03877	0.59	4795	4408	49245	P
0.0079214	3.685	278.8686	0.04656	0.668	4690	7313	23898	P
0.0077346	4.025	276.4174	0.04993	0.711	4677	6597	23922	P
0.0075025	4.608	272.0146	0.05519	0.775	4653	5369	23962	P

0.0073865	5.152	267.679	0.05945	0.823	4628	4222	23996	P
0.0073687	5.716	262.9521	0.06322	0.861	4601	3030	24030	P
0.0074698	6.337	257.4746	0.06658	0.89	4569	1717	24064	P
0.0069496	0.353	308.8866	0.00591	0.082	5703	14818	38657	P
0.0068794	0.967	307.3128	0.01389	0.209	5697	12357	38717	P
0.0070402	1.535	305.2521	0.02011	0.307	5687	10078	38774	P
0.0073802	2.058	302.8405	0.02486	0.38	5674	7976	38829	P
0.0080031	2.663	299.4361	0.02922	0.444	5654	5540	38894	P
0.0084539	2.998	297.2673	0.03107	0.47	5640	4190	38932	P
0.0082097	3.685	275.8601	0.03824	0.54	5497	7618	19257	P
0.0081251	4.025	272.9214	0.04135	0.579	5478	6939	19277	P
0.0080388	4.608	267.4963	0.04629	0.638	5442	5774	19309	P
0.0080249	5.152	261.9943	0.05051	0.683	5404	4685	19338	P
0.0080787	5.716	255.8418	0.05449	0.721	5362	3555	19368	P
0.0082179	6.337	248.5397	0.05835	0.751	5310	2308	19399	P
0.0083499	0.353	306.592	0.00905	0.132	3721	15379	61918	P
0.0074717	0.967	305.4391	0.0217	0.333	3721	12802	62028	P
0.0071198	1.535	304.0235	0.03148	0.487	3719	10413	62130	P
0.007187	2.058	302.4232	0.03884	0.6	3714	8210	62223	P
0.0077328	2.663	300.2172	0.04537	0.699	3707	5657	62330	P
0.008251	2.998	298.8319	0.04806	0.738	3702	4242	62389	P
0.0074236	3.685	286.2829	0.05589	0.826	3648	6359	34797	P
0.0069936	4.025	284.6875	0.05939	0.873	3642	5557	34830	P
0.0064173	4.608	282.0005	0.06444	0.94	3632	4180	34882	P
0.0060629	5.152	279.5486	0.06803	0.986	3622	2894	34924	P
0.0058823	5.716	277.0631	0.06895	0.99	3611	1559	34962	P
0.0059035	6.337	274.3928	0.06958	0.99	3599	87	34996	P
0.0069123	0.353	305.8355	0.00871	0.126	2406	9270	59712	P
0.0066323	0.967	305.4271	0.02041	0.312	2408	7662	59817	P
0.006684	1.535	304.9106	0.02929	0.453	2408	6171	59907	P
0.0069958	2.058	304.3171	0.03585	0.557	2408	4796	59985	P
0.0076724	2.663	303.4895	0.04144	0.644	2407	3204	60068	P
0.0081928	2.998	302.9663	0.04361	0.677	2406	2322	60111	P
0.0090153	3.685	297.6303	0.04909	0.751	2392	3676	30732	P
0.0087102	4.025	296.9229	0.05191	0.794	2391	3218	30754	P
0.0083233	4.608	295.6929	0.05598	0.854	2389	2431	30788	P
0.0081175	5.152	294.5257	0.05881	0.894	2386	1697	30816	P
0.0080625	5.716	293.2956	0.06081	0.921	2383	934	30842	P
0.0081882	6.337	291.9179	0.06187	0.933	2379	94	30866	P
0.0061258	0.353	316.6367	0.00513	0.071	6486	15003	34628	P
0.0061382	0.967	315.0168	0.01215	0.186	6478	12519	34677	P
0.006333	1.535	312.9069	0.01764	0.274	6466	10218	34725	P
0.0066682	2.058	310.4446	0.02184	0.34	6451	8096	34771	P
0.0072423	2.663	306.9749	0.02569	0.398	6427	5638	34825	P
0.0076463	2.998	304.7669	0.02733	0.422	6412	4275	34857	P

0.0077868	3.685	281.5437	0.03404	0.489	6238	8053	17826	P
0.0077064	4.025	278.3629	0.03693	0.526	6215	7345	17843	P
0.0076224	4.608	272.4701	0.04157	0.581	6171	6130	17871	P
0.0076052	5.152	266.4721	0.04554	0.625	6126	4994	17896	P
0.0076497	5.716	259.7444	0.04936	0.661	6073	3814	17923	P
0.0077723	6.337	251.7372	0.05309	0.691	6009	2514	17951	P
0.0077573	0.353	307.7247	0.00787	0.113	4681	16129	51167	P
0.0073113	0.967	306.23	0.01844	0.282	4678	13453	51254	P
0.0072334	1.535	304.3292	0.02668	0.411	4671	10973	51336	P
0.0074464	2.058	302.1386	0.03295	0.507	4662	8686	51413	P
0.008033	2.663	299.0778	0.03861	0.591	4648	6036	51502	P
0.0085149	2.998	297.1399	0.04103	0.624	4638	4567	51552	P
0.0079283	3.685	278.9687	0.04914	0.706	4539	7326	24150	P
0.0076568	4.025	276.5639	0.0526	0.75	4527	6627	24175	P
0.0072906	4.608	272.3119	0.05803	0.817	4504	5426	24215	P
0.007062	5.152	268.198	0.06243	0.867	4482	4304	24249	P
0.0069404	5.716	263.7838	0.06634	0.907	4457	3140	24283	P
0.0069424	6.337	258.7478	0.06981	0.938	4429	1855	24317	P
0.0086072	0.353	304.9539	0.00111	0.005	6647	420	8297	C
0.0074497	0.967	304.7036	0.00149	0.011	6645	1038	8292	C
0.0064	1.535	304.4016	0.00211	0.021	6643	1609	8285	C
0.0054513	2.058	304.0637	0.00293	0.034	6641	2134	8276	C
0.0043753	2.663	303.6012	0.00415	0.053	6638	2741	8264	C
0.0037894	2.998	303.3121	0.00496	0.066	6636	3077	8257	C
0.0024481	3.685	299.6974	0.00768	0.107	6610	6383	35158	C
0.0046475	4.025	299.1688	0.00972	0.139	6607	7832	35123	C
0.0073101	4.608	297.2054	0.01425	0.208	6595	10314	35059	C
0.0085313	5.152	294.1692	0.01974	0.291	6574	12626	34992	C
0.0085097	5.716	289.794	0.02681	0.394	6544	15018	34917	C
0.0069698	6.337	283.5314	0.03639	0.528	6499	17645	34828	C
0.0125099	0.353	304.7582	0.00114	0.005	4828	473	12027	C
0.0089098	0.967	304.5657	0.0017	0.014	4827	1124	12019	C
0.0063243	1.535	304.3562	0.00262	0.029	4825	1726	12008	C
0.0045767	2.058	304.1365	0.00382	0.048	4824	2279	11995	C
0.0033123	2.663	303.8502	0.00562	0.076	4822	2918	11977	C
0.0029616	2.998	303.6769	0.00682	0.095	4821	3272	11965	C
0.0054218	3.685	300.7141	0.01096	0.159	4804	7278	45567	C
0.0065642	4.025	300.1101	0.01413	0.208	4800	8643	45519	C
0.0078619	4.608	298.3986	0.0209	0.311	4790	10980	45431	C
0.0083196	5.152	296.0318	0.02885	0.429	4776	13156	45343	C
0.0080263	5.716	292.7932	0.0388	0.574	4756	15408	45247	C
0.0067993	6.337	288.3034	0.052	0.759	4729	17882	45134	C
0.0119984	0.353	304.0393	0.00118	0.006	3769	445	12183	C
0.0077503	0.967	303.9225	0.00181	0.016	3769	960	12175	C
0.0048431	1.535	303.8072	0.00279	0.031	3768	1436	12164	C

0.0030352	2.058	303.6949	0.00404	0.051	3768	1874	12153	C
0.0019832	2.663	303.5576	0.00589	0.08	3768	2380	12136	C
0.0018803	2.998	303.4782	0.00712	0.1	3768	2660	12126	C
0.0038241	3.685	301.6951	0.01097	0.16	3762	5254	42827	C
0.0064857	4.025	301.3806	0.01383	0.205	3762	6256	42787	C
0.0097593	4.608	300.2589	0.01994	0.3	3759	7972	42713	C
0.0113437	5.152	298.5488	0.02706	0.409	3754	9571	42636	C
0.0114878	5.716	296.0994	0.036	0.544	3746	11225	42549	C
0.0098819	6.337	292.606	0.04769	0.718	3735	13043	42444	C
0.0111455	0.353	302.3133	0.00129	0.008	2220	347	11692	C
0.0055691	0.967	302.2729	0.00204	0.019	2220	639	11685	C
0.0039455	1.535	302.2438	0.00312	0.036	2220	909	11676	C
0.0054549	2.058	302.2241	0.00444	0.057	2221	1157	11667	C
0.0107941	2.663	302.2097	0.00637	0.088	2221	1444	11655	C
0.0154085	2.998	302.2056	0.00761	0.107	2221	1602	11648	C
0.0101172	3.685	301.0212	0.01119	0.163	2219	2652	25454	C
0.0122485	4.025	300.8191	0.01357	0.2	2219	3004	25436	C
0.0148796	4.608	300.2737	0.01835	0.275	2219	3606	25402	C
0.0161686	5.152	299.5381	0.02363	0.357	2218	4168	25367	C
0.0163165	5.716	298.5444	0.02995	0.454	2217	4749	25328	C
0.0150797	6.337	297.1783	0.03795	0.577	2215	5388	25280	C
0.0060509	0.353	310.8552	0.00651	0.092	5764	16106	41533	P
0.0062338	0.967	309.2501	0.01506	0.23	5759	13440	41596	P
0.006545	1.535	307.1259	0.02173	0.335	5748	10971	41656	P
0.0069523	2.058	304.6265	0.02685	0.414	5735	8694	41714	P
0.0075678	2.663	301.0852	0.03153	0.483	5713	6055	41783	P
0.0079752	2.998	298.8245	0.03355	0.511	5699	4593	41822	P
0.0075937	3.685	276.6709	0.04133	0.587	5550	8351	19734	P
0.0075378	4.025	273.6607	0.04471	0.629	5530	7650	19754	P
0.007487	4.608	268.0808	0.05013	0.693	5493	6446	19787	P
0.0074909	5.152	262.3977	0.05481	0.743	5455	5321	19816	P
0.0075472	5.716	256.0201	0.05925	0.786	5410	4153	19846	P
0.0076707	6.337	248.4261	0.06373	0.822	5356	2864	19878	P
0.0045341	0.353	300.5211	0.00336	0.04	6550	7470	16133	P
0.0050422	0.967	299.6984	0.00691	0.095	6546	6280	16152	P
0.0055371	1.535	298.6147	0.0097	0.138	6539	5177	16170	P
0.0060141	2.058	297.3428	0.01183	0.171	6530	4160	16187	P
0.0065912	2.663	295.5436	0.0138	0.2	6518	2983	16208	P
0.0069224	2.998	294.3961	0.01465	0.212	6509	2330	16219	P
0.0079649	3.685	281.8372	0.01804	0.254	6412	5230	12763	P
0.0081069	4.025	279.9707	0.01973	0.277	6398	4709	12773	P
0.0083973	4.608	276.3728	0.02235	0.311	6371	3813	12788	P
0.0087215	5.152	272.5625	0.02446	0.337	6341	2977	12803	P
0.0091121	5.716	268.1505	0.02634	0.358	6306	2109	12817	P
0.0096062	6.337	262.7489	0.02804	0.375	6262	1152	12831	P

0.0060769	0.353	313.4054	0.00123	0.007	4976	700	10013	C
0.0051127	0.967	313.2734	0.00188	0.018	4975	1253	10006	C
0.0043209	1.535	313.1088	0.00281	0.033	4975	1764	9998	C
0.003677	2.058	312.921	0.00393	0.051	4975	2234	9988	C
0.003034	2.663	312.6606	0.00557	0.078	4974	2777	9974	C
0.0027249	2.998	312.4964	0.00663	0.095	4974	3078	9965	C
0.0043209	3.685	309.811	0.01022	0.152	4960	6711	46835	C
0.0060587	4.025	309.2987	0.01299	0.196	4959	8143	46792	C
0.0081197	4.608	307.6769	0.01905	0.293	4952	10595	46711	C
0.0089959	5.152	305.3166	0.02627	0.405	4942	12879	46627	C
0.0088371	5.716	302.0063	0.03542	0.546	4928	15242	46533	C
0.0074057	6.337	297.345	0.04763	0.728	4906	17838	46420	C
0.0114453	0.353	331.4008	0.00109	0.005	5225	485	10990	C
0.0080883	0.967	331.2173	0.00158	0.013	5224	1110	10984	C
0.005684	1.535	331.024	0.00238	0.027	5223	1687	10975	C
0.004066	2.058	330.8261	0.0034	0.045	5223	2218	10966	C
0.0029071	2.663	330.5732	0.00493	0.071	5222	2832	10952	C
0.0025943	2.998	330.4222	0.00594	0.088	5222	3172	10943	C
0.0032425	3.685	327.5856	0.00926	0.144	5207	6688	49270	C
0.0053882	4.025	327.1534	0.01183	0.188	5206	8238	49228	C
0.0079662	4.608	325.6228	0.01755	0.284	5201	10893	49151	C
0.0091171	5.152	323.2954	0.02442	0.398	5191	13367	49072	C
0.0090312	5.716	319.9658	0.03322	0.541	5176	15927	48983	C
0.0074307	6.337	315.2202	0.04498	0.727	5155	18740	48876	C
0.0138263	0.353	351.5863	0.00106	0.005	5059	398	11780	C
0.0089209	0.967	351.4079	0.0015	0.013	5058	1032	11774	C
0.0055284	1.535	351.2392	0.00226	0.026	5058	1619	11766	C
0.0033782	2.058	351.0809	0.00324	0.044	5057	2159	11756	C
0.0020551	2.663	350.8942	0.00474	0.072	5057	2782	11743	C
0.0018597	2.998	350.7891	0.00573	0.09	5057	3127	11735	C
0.0032482	3.685	348.5404	0.009	0.148	5047	6652	49552	C
0.005371	4.025	348.161	0.01153	0.194	5047	8129	49515	C
0.0079314	4.608	346.8243	0.01712	0.294	5043	10660	49445	C
0.0090903	5.152	344.7954	0.02378	0.412	5035	13019	49375	C
0.009038	5.716	341.8951	0.03223	0.56	5025	15460	49295	C
0.0075038	6.337	337.7635	0.04346	0.751	5009	18144	49200	C
0.0146947	0.353	304.0153	0.00081	0	4820	606	13957	C
0.0287501	0.967	303.8248	0.00081	0	4910	1352	13952	C
0.0312092	1.535	303.5778	0.00081	0	5058	2042	13945	C
0.0245129	2.058	303.2903	0.00082	0	5251	2678	13937	C
0.0060498	2.663	302.8858	0.00653	0.09	4765	3412	13927	C
N/A	2.998	302.6286	0.00793	0.112	4764	3819	13920	C
0.0082828	3.685	298.5671	0.01201	0.174	4743	6208	38090	C
0.0092589	4.025	297.7462	0.01474	0.216	4740	7336	38069	C
0.0103187	4.608	295.6584	0.02055	0.304	4730	9269	38027	C

0.0106081	5.152	292.9353	0.0273	0.405	4718	11071	37982	C
0.010195	5.716	289.3222	0.03578	0.529	4701	12936	37927	C
0.0089004	6.337	284.4138	0.047	0.687	4678	14986	37860	C