BUBBLE SIZE MEASUREMENTS IN A COCURRENT BUBBLE COLUMN FILLED WITH VARIOUS CONSISTENCIES OF COPY PAPER

Project F00903

Report 8

to the

MEMBER COMPANIES OF THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

March 1999

INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

Atlanta, Georgia

BUBBLE SIZE MEASUREMENTS IN A COCURRENT BUBBLE COLUMN FILLED WITH VARIOUS CONSISTENCIES OF COPY PAPER

Project F00903

Report 8

A Progress Report

to the

MEMBER COMPANIES OF THE INSTITUTE OF PAPER SCIENCE AND TECHNOLOGY

By

T.J. Heindel and A.E. Garner

March 1999

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

Bubble size control is important for effective flotation deinking. However, before it can be controlled, it must be measured. This study utilized flash x-ray radiography (FXR) to measure bubble size in various copy paper suspensions flowing through a cocurrent bubble column. The majority of the bubbles were small ($d \leq 12$ mm), and the distribution of these small bubbles was adequately described by a lognormal distribution.

For the conditions of this study, the lognormal distribution was independent of copy paper consistency ($0\% \leq C \leq 1.5\%$), superficial gas velocity ($1 \text{ cm/s} \leq \upsilon_g \leq 4 \text{ cm/s}$), and column height ($15 \text{ cm} \leq H \leq 140 \text{ cm}$). A few very large bubbles ($d > 12$ mm) were also recorded at each test condition. These bubbles comprised a small number fraction of the bubble population, but increased in number with increasing copy paper consistency.

Now that the bubble size distribution is known for a wide range of conditions in a cocurrent bubble column, bubble size control and modification strategies can be investigated. Specifically, transforming the large bubbles ($d > 12$ mm) into small bubbles ($d \leq 12$ mm) is of interest because, although they comprise a small number fraction, they utilize a large gas volume. It is hypothesized that developing techniques to transform this gas volume into small bubbles will increase the surface area to which contaminants can attach. This will lead to improved deinking efficiencies for a fixed gas flow, or allow the gas flow rate to be reduced while maintaining the removal efficiency.

2. INTRODUCTION

Quantifying gas flow characteristics (i.e., flow regime, gas holdup, bubble size distribution, etc.) in gas/liquid/solid suspensions is important to many areas related to the pulp and paper industry. Examples where these complex multiphase flows exist include flotation deinking, bleaching with gaseous chemicals, direct contact steam heating, and air removal from stock and coating flows. This research program utilizes flash x-ray radiography (FXR) to visualize gas flows in fiber suspensions at consistencies common to flotation deinking (~0.8-1.2%). Image analysis is then performed on the resulting FXR images to determine bubble size distributions in these suspensions.

Report 3 of PAC Project F00903 [1] presented preliminary work in this area, where the FXR technique and procedure were described in detail, and bubble size measurements were obtained in a quiescent bubble column of 0-1.5% ONP (old newspaper) suspensions. General conclusions from this initial research included:

1. FXR was a useful tool to visualize gas flows in fiber suspensions.
2. For the conditions of this study, air bubble rise characteristics and bubble size were dependent on ONP fiber consistency.
3. For the conditions of this study, conclusions obtained in a single air/water system were not applicable at fiber consistencies common to flotation deinking.

Additional data were collected for different fiber systems in a quiescent bubble column. Report 5 of PAC Project F00903 [2] summarized this work, addressing four different experimental systems: (1) ONP systems with various chemistry and chemistry concentrations; (2) Northern Bleached Softwood Kraft (NBSK) systems with various consistencies but no added chemistry; (3) a copy paper system with no added chemistry; and (4) an ONP system with no added chemistry but at a higher gas flow rate. General conclusions from this research included:

1. Clear trends for the various ONP chemistries were difficult to ascertain because the fiber network structure was different from test to test, which had a larger impact on the bubble size than the change in system chemistry for the given air flow rate (0.25 standard L/min).
2. The NBSK studies were conducted at a higher air flow rate (2 standard L/min) and allowed the system to remain well mixed. The majority of the bubbles in this system were smaller than 12 mm in diameter, with a peak in the bubble population in the 2-3 mm range. The bubbles in this range all had a similar average bubble size (~3 mm) for all NBSK consistencies addressed (0, 0.5, 1, 1.5%), but the relative frequency decreased with increasing consistency. There were a few bubbles that had equivalent bubble diameters greater than 12 mm, and these were usually much larger than 12 mm in diameter. The number of these bubble types increased with increasing NBSK consistency and they acted as "mobile mixers," keeping the smaller bubbles uniform and the fiber suspension well-mixed and homogeneous.
3. Similar results to those obtained at 1% NBSK with an air injection rate of 2 standard L/min were obtained when the fiber type was changed to 1% copy paper or 1% ONP at the same air injection rate.

This report continues this FXR research and summarizes bubble size measurements obtained in a cocurrent bubble column filled with copy paper suspensions at consistencies up to 1.5%. The experimental procedures will first be reviewed and then bubble size results will be presented for copy paper systems in cocurrent flow. The report will end with conclusions from this work and outline possible future FXR studies in fiber (and other) suspensions.

3. EXPERIMENTAL METHODS

The experimental methods used in this research will be described in this section. A new flow loop was constructed for these experiments and it will be described in detail. The fiber type will then be briefly described. Since the FXR and image analysis procedures have been presented elsewhere [1-3], these areas will only be summarized. This section will conclude with a discussion of the bubble size data reduction and presentation procedures used, and test conditions covered in this report.

3.1 Experimental Flow Loop

Figure 1 is a schematic of the cocurrent flow loop used in this research. Stock, which is classified as water or a water/fiber suspension, was pumped from a 150 L (40 gal) holding tank with a constant output Goulds centrifugal pump. Two metering valves controlled how much stock returned to a second 150 L (40 gal) holding tank, and how much stock passed through the test section. Before entering the base of the vertical bubble column, the stock passed through a Krohne magnetic flow meter. Stock entered at the column base, exhausted at the column top, and then returned to the second holding tank. Air was also injected at the column base through a fine sintered polyethylene sparger with an average pore size of 50 μm. The air traveled in the same direction as the stock, which defines the bubble column as cocurrent. The two holding tanks contained baffles to maximize the stock retention time, allowing time for air to escape. The flow loop was designed such that countercurrent flow could be produced if desired, or, with slight modifications to the framing, the column could be horizontally oriented.

The bubble column consisted of two 1 m sections attached end-to-end with a rectangular cross section of 10 cm × 2 cm. The bottom and top of the column contained a channel expansion and contraction region to convert pipe flow to channel flow and back to pipe flow. The entire column was fastened to an adjustable support stand. X-rays were taken of air/water or air/water/fiber mixtures at two locations, encompassing channel regions H = 15-40 cm and H = 115-140 cm, where H is the channel height measured from the base of the channel bottom section (Fig. 1). These two regions will be referred to as lower and upper column regions, respectively.

The x-ray unit was a 300 keV HP 43733A flash x-ray system (currently supported by Primex Physics International), which generated a 30 nanosecond x-ray pulse. The x-ray tube head was mounted in a locking vertical slide to allow x-ray exposures at various column heights. The x-ray aperture was located approximately 2 m (79 inches) from the bubble column, and the tube head was oriented perpendicular to the column face. An x-ray film cassette was mounted directly behind the column such that the x-ray aperture was coincident with the film center.

The flow loop was charged with approximately 150 L (40 gal) of the desired stock. The pump was turned on with the by-pass line completely open and the main flow line closed. The pump was operated in this fashion for a few minutes to ensure that the stock was well mixed. The main flow line was then slowly opened to fill the column approximately to the 1 m mark, and then the main line was closed. The air flow rate was then initiated and adjusted to the desired value. The main flow line was then slowly reopened and adjusted until the desired stock flow rate was reached. FXR images were acquired while the air and stock flow rates were operated under steady-state conditions.

3.2 Fiber Description

Experiments were initially performed in an air/water system (without fiber), comprised of compressed and filtered building air and city water, to form base-line conditions. The air/water/fiber system was composed of city water and unprinted copy paper (Union Camp Yorktown xerographic paper). The copy paper was reslushed at a consistency of approximately 11% using a Lamort high consistency pulper. The fiber consistencies addressed in this study were 0.5, 1, and 1.5%, and were prepared by diluting samples of the high consistency stock with city water until the desired consistency was reached. A sample of the copy paper was analyzed to determine a weight-weighted fiber length of 2.0 mm (Kajaani FS-100 fiber length analyzer) and an ash content of 6.6% (TAPPI Method T413 om-93 [4]).

3.3 FXR Procedures

Details of the flash x-ray radiography (FXR) procedures have been presented elsewhere [1-3] and will not be repeated here. The only difference in the procedures of the study and those previously reported was the distance between the bubble column and the x-ray source – it was increased slightly in this study. Additionally, x-rays were taken at only two column positions (approximately 1 m apart) and image analysis was completed at each location.

3.4 Image Analysis Procedures

Once the FXR images acquired in this study were developed, they were analyzed using image analysis software. The x-ray was placed on a light table and a 7.6 cm × 7.6 cm region of interest was isolated to perform image analysis. Since the x-rays were black and white, the image was digitized using Optimas 5.2 with the 8-bit mono setting (as opposed to the 16-bit RGB default setting) and saved as a Tiff file. The resulting electronic image was then enhanced (to increase the contrast between the bubbles and the background) using Scion Image. The image was then electronically returned to Optimas 5.2 to record the equivalent bubble diameter, defined as the diameter of a circle whose area is equal to that of the recorded bubble. This process was repeated until all regions with bubbles on the x-ray were analyzed. Care was taken not to record a bubble more than once if regions overlapped. The equivalent bubble diameters were automatically exported to an Excel spreadsheet for statistical analysis.

3.5 Data Reduction Procedures

The equivalent bubble diameter data was categorized into different bubble size ranges to determine the percentage of the total bubble population in each size range. This value is typically termed the number density or the relative frequency, and is equivalent to the probability that a random bubble will fall within a given size range. The cumulative number density is the sum of all bubbles less than or equal to a given size range. Examples of generic number density and cumulative number density plots are shown in Fig. 2 for the generic data shown in Table 1. The equivalent bubble diameter data obtained in this study are presented in a similar fashion.

By plotting the equivalent bubble diameter distributions as cumulative number densities, comparisons can be easily made with known distribution functions. Three such distributions are used in this study; (1) the normal, (2) the lognormal, and (3) the gamma distribution. Since the bubble size is defined only for d > 0, where d is the equivalent bubble diameter, the cumulative normal distribution is given by

$$Cum_N = \int_0^x \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{y-\mu}{\sigma}\right)^2\right] dy \tag{1}$$

where y is a dummy variable and x is the parameter of interest (i.e., the bubble diameter), and μ and σ are the mean and standard deviation of the bubble population. The cumulative lognormal distribution is given by

$$Cum_{LN} = \int_0^x \frac{1}{y\sigma_{LN}\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\ln(y)-\mu_{LN}}{\sigma_{LN}}\right)^2\right] dy \tag{2a}$$

where μ_{LN} and σ_{LN} are the mean and standard deviation of the natural logarithm of the bubble diameters. These values are not equivalent to μ and σ, but can be related by [5]

$$\mu_{LN} = \ln(\mu) - \frac{1}{2}\sigma_{LN}^2 \tag{2b}$$

$$\sigma_{LN}^2 = \ln\left[1+\left(\frac{\sigma}{\mu}\right)^2\right] \tag{2c}$$

The cumulative gamma distribution is given by

$$Cum_G = \int_0^x \frac{1}{\beta^\alpha \Gamma(\alpha)} y^{\alpha-1} e^{-y/\beta} dy \tag{3a}$$

where $\Gamma(\alpha)$ is the gamma function and β and α are parameters that describe it and are related to μ and σ by [6]

$$\mu = \alpha\beta \tag{3b}$$

$$\sigma^2 = \alpha\beta^2 \tag{3c}$$

These three distributions will be compared to the experimental bubble population cumulative number densities presented in Section 4.

3.6 Test Conditions

The experimental conditions addressed in this study include four copy paper consistencies of C = 0, 0.5, 1, and 1.5% flowing through the cocurrent bubble column. FXR images and bubble size distributions were obtained at two column positions, the lower column region encompassed H = 15-40 cm, while the upper column region included H = 115-140 cm. The superficial liquid velocity (υ_ℓ) is defined as the volumetric liquid flow rate divided by the column cross-sectional area, and was fixed for all test conditions at $\upsilon_\ell = 2$ cm/s, corresponding to a volumetric liquid flow rate of 2.4 L/min. A similar definition defined the superficial gas velocity (υ_g), which was specified at one of three values, $\upsilon_g = 1$, 2, or 4 cm/s, corresponding to a volumetric gas flow rate of 1.2, 2.4, or 4.8 standard L/min, respectively. Julien Saint Amand [7] indicates that in flotation deinking equipment, superficial velocities range from 0.5 to 5 cm/s, with 1-2 cm/s being the most common. The experiments completed in this study were selected to encompass this range. No additional system chemistry (i.e., soaps, collectors, etc.) was added during the experiments. The specific test conditions are summarized in Table 2.

4. RESULTS

Flash x-rays of an air/water and an air/water/copy paper system at various consistencies (C = 0.5, 1, and 1.5%) have been obtained in a cocurrent rectangular bubble column. Two imaging locations were selected, H = 15-40 cm and H = 115-140 cm, where the column height, H, is measured from the column bottom. The fluid (stock) flow rate was fixed for all experiments at a superficial liquid velocity of $\upsilon_\ell = 2$ cm/s. The air flow rate was set to one of three superficial gas velocities of $\upsilon_g = 1$, 2, or 4 cm/s. Individual consistency results will first be presented, and then comparisons between the various consistencies will be made.

4.1 Air/Water System

Representative FXR images of the air/water system at each column location and superficial gas velocity are shown in Fig. 3. The 20×25.5 cm x-ray film is oriented such that the long dimension is in the flow direction. The film extended beyond the column width by 5 cm on each side. These regions have been digitally removed from the images presented in this report to increase clarity. As stated in previous reports [1, 2], the reproduced and reduced images do have some loss of detail, but are provided here for qualitative observations and are representative of the originals. All observations and measurements presented in this report are based on the original FXR images, which are available at IPST.

Figure 3 reveals that all conditions show many "small" bubbles (the dark regions) and a few "large" bubbles. The differentiation between these bubble classes will be detailed below. The large bubbles oscillated in a serpentine pattern as they rose through the bubble column, creating turbulent eddies as they rose. As the superficial gas velocity increased, the size of the large bubbles increased and they rose much faster, increasing the turbulence in the column. This is reasonable since more air is being introduced into the system over a given time period. The increase in turbulence was more apparent between the 1 and 2 cm/s superficial gas velocities. Backmixing was also observed at each superficial gas velocity, and was confined to the sides of the column, outside the serpentine flow path. Dead zones were also observed in these regions where small bubbles became trapped in the backmixed flow. Eventually, these bubbles migrated into the main rise region and rose with the other bubbles. These observations were apparent at both the lower (H = 15-40 cm) and upper (H = 115-140 cm) column regions. For a fixed superficial gas velocity, it also appeared that the size of the large air bubbles increase from the lower to upper column region.

Image analysis was performed on each FXR image (and others) to determine individual bubble sizes and bubble size distributions. Six FXR images were analyzed for each condition. The resulting statistical data are summarized in Table 3, and the individual bubble size measurements can be found in Appendix A1. One observation in Table 3 is that the maximum bubble size (abbreviated by "Max" in the table) for each column position is larger than 20 mm, which corresponds to the column depth. These large bubbles are influenced by the column walls and are not spherical. It is also clear that the largest bubble size increases with increasing superficial gas velocity and column height. Trends in the average bubble size are difficult to discern due to the large standard deviations in the data (abbreviated by "Stdev" in the table), which is a result of the few very large bubbles present in each data set.

Bubble size distributions for these various conditions are shown in Fig. 4. The solid symbols represent the lower column data (H = 15-40 cm), and the open symbols represent the upper column data (H = 115-140 cm). The majority of the bubbles fall in the size range where the equivalent bubble diameter is less than ~7 mm. Comparing the lower and upper column data in this size range, the upper column distributions are shifted to slightly larger bubble sizes. Trends between the different superficial gas velocities are difficult to quantify when the data are presented in this fashion.

Figure 4 also shows that only a small percentage of the bubble population has an equivalent bubble diameter larger than 12 mm. This demarcation in size is significant for our column geometry. Clift et al. [8] state that bubbles with an equivalent diameter d rising through a cylindrical column of diameter D will be unaffected by the cylinder walls if $d \leq 0.6D$. Extending this idea to a bubble rising between two parallel plates, wall effects could be neglected when $d \leq 0.6t$, where t is the distance separating the parallel plates. Approximating the rectangular bubble column used in this study as two parallel plates reveals that wall effects can be neglected when $d \leq 12$ mm. Therefore, "small" bubbles in this study will refer to those unaffected by wall effects (i.e., $d \leq 12$ mm) and "large" bubbles are those influenced by wall effects (i.e., $d > 12$ mm).

The bubble size number density distributions in Fig. 4 can easily be converted to cumulative number density distributions, as shown in Fig. 5. This figure clearly shows the shift to larger bubble sizes from the lower to upper column region for all superficial gas velocities. It is hypothesized that this shift is due to bubble coalescence as they rise up the column. The effect of superficial gas velocity on bubble size is not as clear. In the lower column region, the $\upsilon_g = 2$ cm/s curve is the left-most curve, indicating a higher frequency of smaller bubbles than the other two superficial gas velocities. The $\upsilon_g = 4$ cm/s curve is the right-most curve, implying a lower frequency of smaller bubbles. However, the difference between the two curves is not too significant. In the upper column region, the cumulative bubble size distributions are similar for each superficial velocity.

In Fig. 5, 95% of all bubbles for these conditions have an equivalent bubble diameter less than 7 mm. Additionally, all cumulative number densities have a similar shape, suggesting that they belong to the same distribution family. Equations (1) - (3) were used in an attempt to fit the experimental data to normal, lognormal, and/or gamma distributions. These distributions are discussed in detail in Section 3.5. The distribution parameters, obtained from the experimental data and used in these equations, are summarized in Table 4. As shown in Fig. 6, the lognormal distribution (the solid line) is the closest fit to the experimental data, but it is still unsatisfactory. It is hypothesized that the few large bubbles present in the total bubble population have a significant influence on the distribution parameters shown in Table 4. These parameter values produce the skewed distribution fits.

Focusing on bubbles unaffected by wall effects (i.e., $d \leq 12$ mm) produces different results. Table 5 represents the statistical summary of all the air/water data with equivalent bubble diameters less than or equal to 12 mm. Note that the total number of bubbles with equivalent bubble diameters greater than 12 mm (the last line in the table) is a small percentage of the bubble population for each test condition. Neglecting these large bubbles, distribution parameters for the normal, lognormal, and gamma distributions are generated and summarized in Table 6. Figure 7 displays these distributions and equivalent bubble size data for all air/water test conditions. All data with negligible wall effects ($d \leq 12$ mm) are well characterized by the lognormal distribution with the parameters shown in Table 6. The gamma distribution also follows the data closely, but not as well as the lognormal distribution.

The lognormal parameters shown in Table 6 all have similar magnitudes. These values were averaged for the lower, upper, and overall column μ_{LN} and σ_{LN} average values, producing

<u>Lower Column Average:</u> $\mu_{LN} = 1.11$ (4a)

$$\sigma_{LN} = 0.38 \quad (4b)$$

Upper Column Average: $\mu_{LN} = 1.29$ (5a)

$$\sigma_{LN} = 0.33 \quad (5b)$$

Overall Column Average: $\mu_{LN} = 1.20$ (6a)

$$\sigma_{LN} = 0.36 \quad (6b)$$

Lognormal distributions with these parameters are shown in Fig. 8 with all of the air/water data where $d \leq 12$ mm. As expected, the lower and upper column data are better described by the lower ($R^2 = 0.990$) and upper ($R^2 = 0.998$) column average distributions, respectively, because there are differences between the two column locations. However, since all data follow a similar shape, the overall column average lognormal distribution ($R^2 = 0.978$) provides a good first-order approximation to all air/water data where $d \leq 12$ mm.

4.2 0.5% Copy Paper System

Figure 9 shows representative FXR images of 0.5% copy paper fiber suspensions flowing through the cocurrent bubble column at three different superficial gas velocities and two column locations. These images are similar to the air/water images (Fig. 3). The large bubbles rose through the column in a serpentine pattern and backmixing was apparent outside the serpentine rise region. Increasing the superficial gas velocity produced a more turbulent flow, larger and more "large" bubbles, and large bubbles occupying a wider column region as they rose. The number density of small bubbles also appeared to decrease in the lower column region as the superficial gas velocity increased, while the frequency of large bubbles increased. A significant difference was not observed in the upper column region. Detailed comparisons of the consistency effects will be presented in Section 4.5.

Six FXR images from each test condition were analyzed to determine the bubble size distributions. The statistical summaries of these data are presented in Table 7 and the raw data are found in Appendix A2. The maximum recorded bubble size increases with increasing superficial gas velocity and column height. Additionally, the maximum bubble size recorded in the 0.5% copy paper suspension is larger than that in the air/water system for each superficial velocity and column height. However, only a small percentage of the overall bubble population is considered to be large (i.e., those influenced by wall effects – $d > 12$ mm). This is clearly shown in Fig. 10 where the bubble size number density is shown for all 0.5% copy paper data. Less than 2.5% of each bubble population has an equivalent diameter greater than 12 mm. The majority of the bubbles are less than 8 mm in diameter, and similar trends are observed for all test conditions.

The similarity in the data is best shown when the bubble size cumulative number density is plotted for all conditions (Fig. 11). The superficial gas velocity has a small influence on the bubble size in the lower column region (H = 15-40 cm), where increasing the superficial gas velocity shifts the bubble size to slightly larger diameters. This trend is not observed in the upper column region (H = 115-140 cm), where the bubble size is unaffected by superficial gas velocity changes in the range of 1 cm/s $\leq \upsilon_g \leq$ 4 cm/s. Additionally, the bubble size distributions in the upper column region fall in the middle of those observed in the lower column region.

The presence of fiber does have an effect on the large bubbles ($d > 12$ mm) in the column. The large bubbles in the 0.5% consistency system are larger and occur at a slightly higher frequency than those in the air/water system. It is hypothesized that any bubble size variations in the small bubbles ($d \leq 12$ mm) observed in the lower column region are diminished due to turbulent mixing in the presence of fibers. Turbulence is created primarily by the very large bubbles that periodically ascend the column. These bubbles shed turbulent eddies that disrupt the majority of the bubbles (i.e., the small bubbles). The presence of fibers hinders the coalescence of the small bubbles (which was observed in the air/water system), and results in less variation in the bubble size distributions for the various superficial gas velocities. This is not observed in the lower column region because the very large bubbles that create the turbulence form as they rise through the column. Hence, there is a development length that extends beyond the lower column region where the FXR images are acquired.

Figure 12 shows the attempt to fit all of the 0.5% copy paper data to known distributions with the various parameters specified in Table 8. All three distributions do a poor job of describing these data. However, neglecting those bubbles that are influenced by the column walls (d > 12 mm) improves the comparisons considerably. Table 9 summarizes the statistical data for all bubbles ≤ 12 mm. Note the last line in the table where only a small percentage of the total bubble population for each test condition falls in the region where d > 12 mm. However, this percentage has increased from that recorded for the air/water system under the same superficial velocity and column height conditions. Using Eqs. (1) - (3) and the parameters outlined in Table 10, Fig. 13 reveals the distribution comparisons for all data unaffected by wall effects in our experimental setup. Observe how well the lognormal distribution characterizes the data for all test conditions at a copy paper consistency of 0.5%.

The lognormal distribution parameters in Table 10 were averaged for the lower, upper, and overall column data, resulting in:

Lower Column Average: $\mu_{LN} = 1.16$ (7a)

$\sigma_{LN} = 0.40$ (7b)

Upper Column Average: $\mu_{LN} = 1.17$ (8a)

$\sigma_{LN} = 0.44$ (8b)

Overall Column Average: $\mu_{LN} = 1.16$ (9a)

$\sigma_{LN} = 0.42$ (9b)

These distributions, as well as all the 0.5% copy paper data where d ≤ 12 mm, are shown in Fig. 14. Since the upper column data fall in between the lower column data, the overall column lognormal distribution does a very good job at describing the 0.5% experimental data. For completeness, the R^2 values for the lower, upper, and overall column lognormal distributions are 0.990, 0.998, and 0.994, respectively.

4.3 1% Copy Paper System

Figure 15 shows sample FXR images for the 1% copy paper suspension at two column locations and three superficial gas velocities. The serpentine flow pattern and backmixing was also observed at this consistency, but it was not as strong as that from the lower consistencies. Small bubbles were observed in all radiographs. As observed at 0.5% consistency, the number density of small bubbles decreased with increasing superficial gas velocity. Increasing the superficial gas velocity generated larger "large" bubbles throughout the column. This result is also shown in Table 11, where the statistical data are summarized for these test conditions. Appendix A3 tabulates the individual equivalent bubble diameter measurements. The few, large bubbles cause the bubble population standard deviation to be very large, preventing any conclusions to be drawn from the bubble size averages.

The bubble size number density is shown in Fig. 16. All data again follow the same general trends: (1) the majority of the bubbles are less than ~8 mm in diameter with a peak between 2.5 and 3.5 mm, and (2) only a small percentage (< 3.5%) of the total bubble population from each test condition is larger than 12 mm. However, the percentage of large bubbles has increased from that observed at a copy paper consistency of 0.5%.

The bubble population similarity is better shown when the bubble population cumulative number density is plotted (Fig. 17). The distributions are very similar for all test conditions. The lower column region (H = 15-40 cm) may show a slight increase in bubble size with increasing superficial gas velocity. However, in the upper column region (H = 115-140 cm), $\upsilon_g = 2$ cm/s displays a shift to larger bubbles while $\upsilon_g = 4$ cm/s does not. In general, the differences observed for a superficial gas velocity range 1 cm/s $\leq \upsilon_g \leq$ 4 cm/s are small. The data for both column heights follow the same general path until approximately the 60th percentile, where the upper column region shifts to larger bubbles.

These data have been fitted to normal, lognormal, and gamma distributions using Eqs. (1) - (3). The resulting distribution parameters are tabulated in Table 12, and the corresponding distributions and data are plotted in Fig. 18. These distributions do a poor job of describing the data.

Following the procedures used with the 0 and 0.5% data, all 1% copy paper data with $d >$ 12 mm were assumed to be influenced by the column walls and neglected. The resulting statistical summary with $d \leq 12$ mm is shown in Table 13. Less than 3.5% of the bubble population was eliminated through this process. However, using the distribution parameters shown in Table 14 and derived from the remaining data (i.e., $d \leq 12$ mm), the lognormal distribution follows the data very closely (Fig. 19).

Averaging the lower, upper, and overall column lognormal distributions results in the following distribution parameters:

Lower Column Average: $\mu_{LN} = 1.12$ (10a)

$\sigma_{LN} = 0.38$ (10b)

Upper Column Average: $\mu_{LN} = 1.14$ (11a)

$\sigma_{LN} = 0.45$ (11b)

Overall Column Average: $\mu_{LN} = 1.13$ (12a)

$\sigma_{LN} = 0.42$ (12b)

These distributions are compared to all the 1% copy paper data with $d \leq 12$ mm in Fig. 20. The three different distributions are almost identical up to the 60th percentile. Then the distributions deviate slightly, where the lower column distribution ($R^2 = 0.986$) has a slight shift to the left, while the upper column distribution ($R^2 = 0.992$) shifts to the right. However, the overall column average lognormal distribution ($R^2 = 0.986$) is adequate to describe all the 1% copy paper data with $d \leq 12$ mm.

4.4 1.5% Copy Paper System

Representative 1.5% copy paper FXR images are shown in Fig. 21 for the three different superficial gas velocities and two column heights addressed in this study. The same general trend of increasing the maximum bubble size with increasing superficial gas velocity and column height are shown here. Backmixing was not evident at this consistency, and the stock appeared to travel at a "slower pace" (i.e., less turbulent) through the column. The serpentine rise pattern was also not as pronounced compared to the lower consistencies. One observation at this consistency is that small bubbles are observed at each test condition, but the number of small bubbles decreased considerably from that observed at lower consistencies. At a fixed superficial gas velocity, decreasing the number of small bubbles implies one of two possibilities: (1) the overall size of large bubbles has increased or (2) the frequency of large bubbles has increased. Table 15 shows that the maximum bubble size is actually less than that observed at a consistency of 1%. Additionally, visual observations did reveal an apparent increase in the frequency of large bubbles. The statistical summary shown in Table 15 also shows a relatively small bubble population size even though the same number of FXR images (i.e., 6) were analyzed as with the other copy paper consistencies. The individual measurements for the 1.5% copy paper consistency system are tabulated in Appendix A4.

Figure 22 shows the bubble size number density for all 1.5% copy paper data. The general trends are similar to those observed at the other copy paper consistencies, but there is much more scatter for each bubble size range. This is due, in part, to the small population size as noted above. Relative to the total bubble population, the number of bubbles with $d > 12$ mm is much larger than previously observed, and is in the range of 6-12%. This would suggest an increase in the frequency of this bubble size class.

The bubble size cumulative number density is shown in Fig. 23. The distribution similarities are more evident when the data are plotted in this fashion, and they all follow the same general trends.

Figure 24 uses Eqs. (1) - (3) to compare normal, lognormal, and gamma distributions to the 1.5% copy paper bubble size data. The distribution parameters used in these comparisons are summarized in Table 16. All of these distributions provide a poor description of the data.

Neglecting the bubble size data where d > 12 mm results in the statistical summary in Table 17. Note that this filtering neglects at most 12% of the bubble population data. The remaining data have been used to generate normal, lognormal, and gamma distributions with the parameters outlined in Table 18. These distributions are compared to the remaining data (i.e., d ≤ 12 mm) in Fig. 25. The lognormal distributions, using the parameters in Table 18, do an excellent job at describing all the small bubble data (i.e., bubbles with equivalent diameters less than 12 mm).

The lognormal distributions have been combined to produce

Lower Column Average: $\mu_{LN} = 1.32$ (13a)

$\sigma_{LN} = 0.44$ (13b)

Upper Column Average: $\mu_{LN} = 1.25$ (14a)

$\sigma_{LN} = 0.49$ (14b)

Overall Column Average: $\mu_{LN} = 1.29$ (15a)

$\sigma_{LN} = 0.46$ (15b)

These distributions are shown in Fig. 26 for all 1.5% copy paper data with d ≤ 12 mm. The R^2 values for the lower, upper, and overall column distributions are 0.990, 0.984, and 0.986, respectively. The overall lognormal distribution does an adequate job at describing the experimental data.

4.5 Consistency Comparisons

The effect of copy paper consistency is displayed for each superficial gas velocity for the lower column region (H = 15-40 cm) in Figs. 27-29 and for the upper column region (H = 115-140 cm) in Figs. 30-32. All figures show that the percentage of the total bubble population where d > 12 mm increases as the consistency increases, and the largest increase occurs from 1 to 1.5% consistency. This is also evident when comparing the last lines of Tables 5, 9, 13, and 17. Figure 27 shows that the bubble size cumulative number density is similar for the 0, 0.5, and 1% copy paper consistencies when the superficial gas velocity is $\upsilon_g = 1$ cm/s. Increasing the consistency to

1.5% produces the same general distribution shape, but shifted to larger bubble sizes and a much larger percentage with d > 12 mm. These same general trends are observed in the lower column region when the superficial gas velocity is increased to υ_g = 2 and 4 cm/s (Figs. 28 and 29, respectively).

In the upper column region (Figs. 30-32), a different trend is observed. The first 50-70th percentile of the 0% (air/water system) bubble population is larger than the bubbles in the fiber suspensions. This is hypothesized to be the result of fibers preventing the coalescence of small bubbles. Additionally, the 0.5-1.5% consistency suspensions have very similar bubble size distributions in this region. At the larger bubble sizes, the 0% data begins to follow the 0.5 and 1% data, whereas the 1.5% data deviate from it.

Eliminating those bubbles with d > 12 mm produces bubble size cumulative number densities that all follow similar trends (Figs. 33-38). These similarities are more evident when the average lognormal distributions previously developed for each copy paper suspension are used. Figure 39 reveals the average lognormal distributions for the lower column region. The 0, 0.5, and 1% average lognormal distributions are very close to one another, while the 1.5% distribution is shifted to the right. All of the lower column data have been combined to provide an estimate of the bubble size distribution, based on a lognormal distribution with

Lower Column Average: $$\mu_{LN} = 1.18 \quad (16a)$$

$$\sigma_{LN} = 0.40 \quad (16b)$$

This distribution is also shown in Fig. 39 and is labeled "Overall Average". Note that this lognormal distribution does a good job at matching the average distributions for each consistency. The largest discrepancy occurs with the 1.5% average distribution. The lower column average lognormal distribution with the parameters shown above is shown in Fig. 40 with all of the lower column data and has an R^2 value of 0.972.

Figure 41 displays the average lognormal distributions for the upper column region. The 0.5 and 1% distributions follow each other very closely over the entire bubble size range. The

1.5% consistency distribution follows these distributions in the smaller bubble sizes, while the 0% distribution follows them in the larger bubble sizes. Combining all the upper column data yields an overall average lognormal distribution with

<u>Upper Column Average:</u> $\mu_{LN} = 1.21$ (17a)

$\sigma_{LN} = 0.43$ (17b)

This distribution provides a good estimate of the bubble size distribution and is shown in Fig. 42 with all of the upper column data. The resulting curve fit has an R^2 value of 0.984.

Similar comparisons have been made of the average lognormal distributions for the combined lower and upper column region data (Fig. 43). The 0, 0.5, and 1% average lognormal distributions all follow similar trends over the entire bubble size range, and the 1.5% average lognormal distribution has a shift to larger bubble sizes. Combining ***all*** of the experimental bubble size data obtained in this study provides a single lognormal distribution with

<u>Overall Column Average:</u> $\mu_{LN} = 1.20$ (18a)

$\sigma_{LN} = 0.41$ (18b)

This distribution is independent of column position, superficial gas velocity, and copy paper consistency for the conditions addressed in this study and provides a good approximation of the bubble size. It is shown in Fig. 43 as the "Overall Average" curve and plotted in Fig. 44 with all of the experimental data. This curve-fit has an R^2 value of 0.978.

4.6 Comparisons to Quiescent Bubble Column Data

The Northern Bleached Softwood Kraft (NBSK) data discussed in Report 5 [2] has been revisited to compare the bubble size distributions obtained in this study with those from previous research. Only the NBSK sparger data in Report 5 will be used in these comparisons for the following reasons: (1) the data were obtained in a consistency range (0-1.5%) consistent with that of this study; (2) 1% copy paper and 1% ONP suspensions were shown to have similar bubble size distributions to that obtained with 1% NBSK in the quiescent bubble column; and (3) the sparger provided a more repeatable air injection method than the gasket.

The quiescent bubble column used in Report 5 allowed for no bulk fluid movement (i.e., $\upsilon_\ell = 0$). The superficial gas velocity was $\upsilon_g = 0.83$ cm/s, corresponding to a volumetric gas flow rate of 2 standard L/min. The bubble size number density is shown in Fig. 45 for reference, and is the same data as that in Fig. 76 of Report 5 [2]. The major result of Fig. 45 is the similarity in the bubble size distributions for the various NBSK consistencies.

Figure 46 shows these data plotted as bubble size cumulative number densities. All consistencies follow the same cumulative number density curve up to approximately the 55th percentile. The different consistencies eventually asymptote to different constant cumulative number densities when $d < 12$ mm. The few remaining bubbles in the population comprise the large bubbles with $d > 12$ mm. Additionally, the number of these large bubbles increases as consistency increases, which was also observed in the cocurrent bubble column.

Equations (1) - (3) were used to fit normal, lognormal, and gamma distributions to these data. The resulting distribution parameters are summarized in Table 19. Figure 47 shows the distribution comparisons to the experimental data. For the air/water data (0% consistency), the normal distribution is adequate for describing the bubble size distribution, but the lognormal and gamma distribution follow the experimental data more closely. When these three distributions are used to characterize the bubble size distribution in the 0.5% NBSK suspension, the lognormal distribution does the best job of following the experimental data, but it is still not very good. The discrepancy between the data and the various distributions becomes even larger as the NBSK consistency increases and is due to the increased presence of the large bubbles as consistency increases.

By neglecting the small number of bubbles in each NBSK bubble population with $d > 12$ mm, the cumulative number densities of each NBSK distribution with $d \leq 12$ mm are shown in Fig. 48. Normal, lognormal, and gamma distributions are also shown for each NBSK consistency. The specific parameters used to generate these distributions are shown in Table 20. All of the data are best predicted by the lognormal distribution.

Combining all the NBSK data with $d \leq 12$ mm and a consistency range of 0-1.5% yields an average lognormal distribution with the following parameters

$$\underline{\text{NBSK Quiescent Column Average:}}\ \mu_{LN} = 1.03 \quad (18a)$$

$$\sigma_{LN} = 0.45 \quad (18b)$$

This distribution and all the NBSK data with $d \leq 12$ mm are shown in Fig. 49. This lognormal distribution does an excellent job ($R^2 = 0.995$) of characterizing the NBSK bubble size distribution for all consistencies up to 1.5% and $d \leq 12$ mm. It is valid for the quiescent bubble column with $\upsilon_g = 0.83$ cm/s. The data deviate from the lognormal distribution only after the 70th percentile is reached.

Figure 50 compares the average lognormal distribution from the NBSK data to the lower, upper, and overall column average lognormal distributions obtained with copy paper in the cocurrent bubble column. The cocurrent bubble column data have a much wider spread due to the variations in superficial gas velocity, column height, and consistency, but the average lognormal distributions in Fig. 50 provide a good estimate of the bubble size. The quiescent bubble column provides a slightly smaller bubble size, possibly due to the lower superficial gas velocity used in this column. However, in general, the lognormal distributions used to describe the bubble size in the two different experimental setups are very similar, suggesting only a slight difference between the two conditions. This is rather surprising considering the differences between the experimental conditions.

5. CONCLUSIONS

A large amount of bubble size data has been obtained using flash x-ray radiography and a cocurrent bubble column filled with fiber suspensions. Four copy paper consistencies (C = 0, 0.5, 1, and 1.5%), two column positions (H = 15-40 cm and H = 115-140 cm), and three superficial gas velocities (υ_g = 1, 2, and 4 cm/s) were considered in this study. The general conclusions from this investigation include:

- The bubbles recorded in this study fall into two bubble size classes: (1) those affected by the column walls termed large bubbles (d > 12 mm), and (2) those unaffected by the column walls and called small bubbles (d ≤ 12 mm).
- The largest recorded bubbles generally increased in size with increasing superficial gas velocity, column height, and copy paper consistency.
- The number of large bubbles comprised a small percentile of the overall bubble population and increased with increasing copy paper consistency.
- All small bubbles (d ≤ 12 mm) for each test condition were well characterized by a lognormal distribution (Eq. (2)).
- ***All*** small bubble data obtained in this study can be approximated by a lognormal distribution (Eq. (2)) with μ_{LN} = 1.20 and σ_{LN} = 0.41. This distribution has an R^2 value of 0.978 and is ***independent*** of column position, superficial gas velocity, and copy paper consistency for the conditions addressed in this study.
- The bubble size distributions obtained in the cocurrent bubble column used in this study are similar to those obtained using Northern Bleached Softwood Kraft with the sparger air injector in a quiescent bubble column (Report 5 [2]).

6. FUTURE FXR STUDIES

We have shown that the size of small bubbles (d ≤ 12 mm) can be characterized by a lognormal distribution and is (relatively) independent of copy paper consistency, column location, and superficial gas velocity. The next step is to verify this result for selected superficial liquid velocities and fiber types. One additional superficial liquid velocity should be investigated while fixing the fiber consistency and type at 0.5% copy paper and the superficial gas velocity at 2 cm/s. Selected experiments with one additional fiber type (ONP) should also be completed.

After these tests are completed, methods to reduce and/or eliminate the large bubbles in the system should be investigated. This would allow more surface area to be available to which contaminants can attach for a given gas input. It is hypothesized that this will increase the removal efficiency from flotation deinking cells. Alternately, the volumetric gas flow rate could be reduced while maintaining the same removal efficiency.

It is also recommended that the FXR techniques developed in this work be extended to other areas relevant to the pulp and paper industry. Two areas of high interest include bubble size control in oxygen-based bleaching technologies and gas removal from coating flows. In oxygen-based bleaching, FXR can be used to determine the bubble size under actual operating conditions. This information could then be used to develop bubble size control strategies to improve selectivity toward lignin, reduce cellulose degradation, and provide more complete delignification. In coating flows, the presence of air bubbles can produce severe reductions in product quality. Therefore, deaerators are typically used to remove air from the coating before being applied to a substrate. FXR can be used to determine coating deaerator effectiveness, and to develop better air removal techniques.

7. REFERENCES

[1] Heindel, T.J., A Method to Visualize Gas Bubbles in a Pulp Suspension, Institute of Paper Science and Technology, Atlanta, GA, Member Company Report, Project F00903, Report 3 (February 3, 1997).

[2] Heindel, T.J., and Emery, A.E., The Effect of ONP Chemistry and Fiber Type on Gas Bubble Size in a Quiescent Bubble Column, Institute of Paper Science and Technology, Atlanta, GA, Member Company Report, Project F00903, Report 5 (February 12, 1998).

[3] Heindel, T.J., and Monefeldt, J.L., "Observations of the Bubble Dynamics in a Pulp Suspension Using Flash X-ray Radiography," *TAPPI Journal*, **81**(11): 149-158 (1998).

[4] TAPPI, "T 413 om-93 - Ash in Wood, Pulp, Paper, and Paperboard: Combustion at 900°C," TAPPI Test Methods 1996-1997, Atlanta, TAPPI Press (1996).

[5] Ayyub, B.M., and McCuen, R.H., *Probability, Statistics, & Reliability for Engineers*, CRC Press, Boca Raton, Florida, 1997.

[6] Devore, J.L., *Probability and Statistics for Engineers and the Sciences*, Brooks/Cole Publishing Company, Monterey, CA, 1982.

[7] Julien Saint Amand, F., "Hydrodynamics of Flotation: Experimental Studies and Theoretical Analysis," *1997 TAPPI Recycling Symposium*, Atlanta, GA, TAPPI Press, 219-241 (1997).

[8] Clift, R., Grace, J.R., and Weber, M.E., *Bubble, Drops, and Particles*, Academic Press, New York, 1978.

8. TABLES

Table 1: Generic data to show the relationship between number density and cumulative number density distributions and plotted in Fig. 2.

x Value	Number of Occurrences	Number Density (%)	Cumulative Number Density (%)
1	4	2	2
2	14	7	9
3	32	16	25
4	48	24	49
5	44	22	71
6	30	15	86
7	16	8	94
8	8	4	98
9	4	2	100
10	0	0	100
Total	200	100	–

Table 2: Experimental conditions investigated in this study.

Copy Paper Consistency	Superficial Liquid Velocity (cm/s)	Superficial Gas Velocity (cm/s)	Column Location (cm)
0%	2	1	H = 15-40
0%	2	1	H = 115-140
0%	2	2	H = 15-40
0%	2	2	H = 115-140
0%	2	4	H = 15-40
0%	2	4	H = 115-140
0.5%	2	1	H = 15-40
0.5%	2	1	H = 115-140
0.5%	2	2	H = 15-40
0.5%	2	2	H = 115-140
0.5%	2	4	H = 15-40
0.5%	2	4	H = 115-140
1%	2	1	H = 15-40
1%	2	1	H = 115-140
1%	2	2	H = 15-40
1%	2	2	H = 115-140
1%	2	4	H = 15-40
1%	2	4	H = 115-140
1.5%	2	1	H = 15-40
1.5%	2	1	H = 115-140
1.5%	2	2	H = 15-40
1.5%	2	2	H = 115-140
1.5%	2	4	H = 15-40
1.5%	2	4	H = 115-140

Table 3: Statistical data for all of the air/water (0% consistency) data.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	3.50	3.23	3.84	4.18	4.01	3.87
Median (mm)	3.10	2.80	3.27	3.82	3.53	3.61
Min (mm)	1.01	1.02	1.00	1.20	1.31	1.06
Max (mm)	33.90	39.26	39.74	35.90	57.04	64.00
Stdev (mm)	2.27	2.73	3.45	2.53	3.54	2.14
Var (mm^2)	5.15	7.46	11.89	6.42	12.53	4.57
Count	947	800	785	761	954	1350

Table 4: Distribution parameters used in Eqs.(1) - (3) for all air/water (0% consistency) data and plotted in Fig. 6.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	3.50	3.23	3.84	4.18	4.01	3.87
σ	2.27	2.73	3.45	2.53	3.54	2.14
Lognormal Distributions						
μ_{LN}	1.08	0.90	1.05	1.28	1.10	1.22
σ_{LN}	0.59	0.73	0.77	0.56	0.76	0.52
Gamma Distributions						
α	2.38	1.40	1.24	2.73	1.28	3.28
β	1.47	2.31	3.09	1.53	3.12	1.18

Table 5: Statistical data for all of the air/water (0% consistency) data with d ≤ 12 mm.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	3.31	2.98	3.49	4.00	3.76	3.81
Median (mm)	3.09	2.79	3.26	3.81	3.52	3.61
Min (mm)	1.01	1.02	1.00	1.20	1.31	1.06
Max (mm)	11.12	11.95	10.88	11.44	11.19	11.35
Stdev (mm)	1.30	1.19	1.42	1.38	1.28	1.32
Var (mm^2)	1.68	1.41	2.03	1.90	1.65	1.74
Count	936	791	774	754	947	1347
Bubbles > 12 mm (%)	1.2	1.1	1.4	0.9	0.7	0.2

Table 6: Distribution parameters used in Eqs.(1) - (3) for the air/water data with d ≤ 12 mm and plotted in Fig. 7.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	3.31	2.98	3.49	4.00	3.76	3.81
σ	1.30	1.19	1.42	1.38	1.28	1.32
Lognormal Distributions						
μ_{LN}	1.13	1.02	1.17	1.33	1.27	1.28
σ_{LN}	0.38	0.38	0.39	0.34	0.33	0.34
Gamma Distributions						
α	6.52	6.30	6.00	8.40	8.57	8.34
β	0.51	0.47	0.58	0.48	0.44	0.46

Table 7: Statistical data for all air/water/0.5% copy paper data.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	3.53	3.83	4.39	3.66	3.88	4.17
Median (mm)	3.00	3.25	3.58	3.17	3.23	3.35
Min (mm)	1.01	1.02	1.01	1.04	1.08	1.00
Max (mm)	43.04	49.81	53.25	56.81	76.51	75.71
Stdev (mm)	3.42	3.59	4.79	3.23	4.31	5.35
Var (mm^2)	11.66	12.90	22.98	10.41	18.60	28.64
Count	899	1111	988	781	934	861

Table 8: Distribution parameters used in Eqs.(1) - (3) for all 0.5% copy paper data and plotted in Fig. 12.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	3.53	3.83	4.39	3.66	3.88	4.17
σ	3.42	3.59	4.79	3.23	4.31	5.35
Lognormal Distributions						
μ_{LN}	0.93	1.03	1.09	1.01	0.95	0.94
σ_{LN}	0.81	0.79	0.89	0.76	0.90	0.99
Gamma Distributions						
α	1.07	1.13	0.84	1.29	0.81	0.61
β	3.31	3.37	5.23	2.84	4.80	6.87

Table 9: Statistical data for all air/water/0.5% copy paper data with d ≤ 12 mm.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	3.20	3.46	3.76	3.42	3.53	3.67
Median (mm)	2.98	3.22	3.54	3.14	3.21	3.31
Min (mm)	1.01	1.02	1.01	1.04	1.08	1.00
Max (mm)	11.05	11.93	10.50	11.69	10.98	11.36
Stdev (mm)	1.42	1.39	1.55	1.52	1.60	1.74
Var (mm^2)	2.01	1.94	2.39	2.30	2.57	3.04
Count	888	1095	966	772	922	848
Bubbles > 12 mm (%)	1.2	1.4	2.2	1.2	1.3	1.5

Table 10: Distribution parameters used in Eqs.(1) - (3) for the 0.5% copy paper data with d ≤ 12 mm and plotted in Fig. 13.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	3.20	3.46	3.76	3.42	3.53	3.67
σ	1.42	1.39	1.55	1.52	1.60	1.74
Lognormal Distributions						
μ_{LN}	1.07	1.17	1.25	1.14	1.17	1.20
σ_{LN}	0.42	0.39	0.39	0.42	0.43	0.45
Gamma Distributions						
α	5.09	6.16	5.93	5.06	4.84	4.44
β	0.63	0.56	0.63	0.67	0.73	0.83

Table 11: Statistical data for all air/water/1% copy paper data.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	3.99	4.10	4.29	3.95	4.13	4.16
Median (mm)	2.74	3.20	3.23	2.97	3.34	2.86
Min (mm)	1.08	1.15	1.33	1.06	1.05	1.21
Max (mm)	40.79	48.07	67.30	52.28	62.14	96.52
Stdev (mm)	5.75	5.15	5.28	4.59	3.93	7.32
Var (mm^2)	33.02	26.50	27.90	21.10	15.47	53.52
Count	267	441	637	494	510	496

Table 12: Distribution parameters used in Eqs.(1) - (3) for all 1% copy paper data and plotted in Fig. 18.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	3.99	4.10	4.29	3.95	4.13	4.16
σ	5.75	5.15	5.28	4.59	3.93	7.32
Lognormal Distributions						
μ_{LN}	0.82	0.94	0.99	0.95	1.10	0.72
σ_{LN}	1.06	0.97	0.96	0.92	0.80	1.19
Gamma Distributions						
α	0.48	0.63	0.66	0.74	1.10	0.32
β	8.27	6.46	6.51	5.34	3.74	12.86

Table 13: Statistical data for the air/water/1% copy paper data with d ≤ 12 mm.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	2.97	3.34	3.57	3.39	3.71	3.33
Median (mm)	2.69	3.17	3.19	2.93	3.26	2.84
Min (mm)	1.08	1.15	1.33	1.06	1.05	1.21
Max (mm)	11.41	10.28	11.65	10.32	12.00	11.92
Stdev (mm)	1.19	1.26	1.43	1.47	1.71	1.80
Var (mm^2)	1.42	1.58	2.04	2.15	2.93	3.25
Count	258	430	621	482	498	485
Bubbles > 12 mm (%)	3.4	2.5	2.5	2.4	2.4	2.2

Table 14: Distribution parameters used in Eqs.(1) - (3) for the 1% copy paper data with d ≤ 12 mm and plotted in Fig. 19.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	2.97	3.34	3.57	3.39	3.71	3.33
σ	1.19	1.26	1.43	1.47	1.71	1.80
Lognormal Distributions						
μ_{LN}	1.01	1.14	1.20	1.13	1.21	1.08
σ_{LN}	0.39	0.36	0.39	0.41	0.44	0.51
Gamma Distributions						
α	6.18	7.05	6.24	5.33	4.68	3.42
β	0.48	0.47	0.57	0.64	0.79	0.97

Table 15: Statistical data for all air/water/1.5% copy paper data.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	6.36	7.16	6.25	5.69	5.49	5.49
Median (mm)	3.63	3.82	4.01	3.22	3.74	3.32
Min (mm)	1.36	1.22	1.01	1.48	1.31	1.64
Max (mm)	60.18	61.61	53.86	62.55	78.34†	79.70
Stdev (mm)	10.01	10.13	7.90	9.01	6.73	8.85
Var (mm^2)	100.13	102.54	62.48	81.21	45.28	78.37
Count	114	124	216	124	211	242

† The entire bubble was not captured on the radiograph (see Fig. 21).

Table 16: Distribution parameters used in Eqs.(1) - (3) for all 1.5% copy paper data and plotted in Fig. 24.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	6.36	7.16	6.25	5.69	5.49	5.49
σ	10.01	10.13	7.90	9.01	6.73	8.85
Lognormal Distributions						
μ_{LN}	1.23	1.42	1.36	1.11	1.24	1.06
σ_{LN}	1.12	1.05	0.98	1.12	0.96	1.13
Gamma Distributions						
α	0.40	0.50	0.63	0.40	0.66	0.38
β	15.75	14.32	10.00	14.27	8.25	14.29

Table 17: Statistical data for the air/water/1.5% copy paper data with d ≤ 12 mm.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Average (mm)	3.89	4.17	4.36	3.74	4.23	3.89
Median (mm)	3.43	3.56	3.89	3.12	3.55	3.18
Min (mm)	1.36	1.22	1.01	1.48	1.31	1.64
Max (mm)	10.34	11.89	10.93	11.36	11.05	11.73
Stdev (mm)	1.80	2.08	1.90	1.76	2.28	2.10
Var (mm^2)	3.23	4.33	3.62	3.08	5.19	4.40
Count	106	110	199	115	197	227
Bubbles > 12 mm (%)	7.0	11.3	7.9	7.3	6.2	6.2

Table 18: Distribution parameters used in Eqs.(1) - (3) for the 1.5% copy paper data with d ≤ 12 mm and plotted in Fig. 25.

Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Normal Distributions						
μ	3.89	4.17	4.36	3.74	4.23	3.89
σ	1.80	2.08	1.90	1.76	2.28	2.10
Lognormal Distributions						
μ_{LN}	1.26	1.32	1.38	1.22	1.31	1.23
σ_{LN}	0.44	0.47	0.42	0.45	0.51	0.51
Gamma Distributions						
α	4.69	4.01	5.25	4.52	3.44	3.43
β	0.83	1.04	0.83	0.83	1.23	1.13

Table 19: Distribution parameters used in Eqs.(1) - (3) for the NBSK data from Report 5 [2] and plotted in Fig. 47.

NBSK Consistency (%)	0	0.5	1	1.5
Superficial Liquid Velocity (cm/s)	0	0	0	0
Superficial Gas Velocity (cm/s)	0.83	0.83	0.83	0.83
Normal Distributions				
μ	3.03	3.53	4.16	6.26
σ	1.24	3.65	5.82	9.29
Lognormal Distributions				
μ_{LN}	1.03	0.90	0.88	1.25
σ_{LN}	0.39	0.85	1.04	1.08
Gamma Distributions				
α	5.97	0.94	0.51	0.45
β	0.51	3.77	8.14	13.8

Table 20: Distribution parameters used in Eqs.(1) - (3) for the NBSK data from Report 5 [2] with $d \leq 12$ mm and plotted in Fig. 48.

NBSK Consistency (%)	0	0.5	1	1.5
Superficial Liquid Velocity (cm/s)	0	0	0	0
Superficial Gas Velocity (cm/s)	0.83	0.83	0.83	0.83
Normal Distributions				
μ	3.03	2.99	3.07	3.28
σ	1.24	1.17	1.61	1.87
Lognormal Distributions				
μ_{LN}	1.03	1.03	1.00	1.05
σ_{LN}	0.39	0.37	0.49	0.53
Gamma Distributions				
α	5.97	6.53	3.63	3.07
β	0.51	0.46	0.84	1.07

9. FIGURES

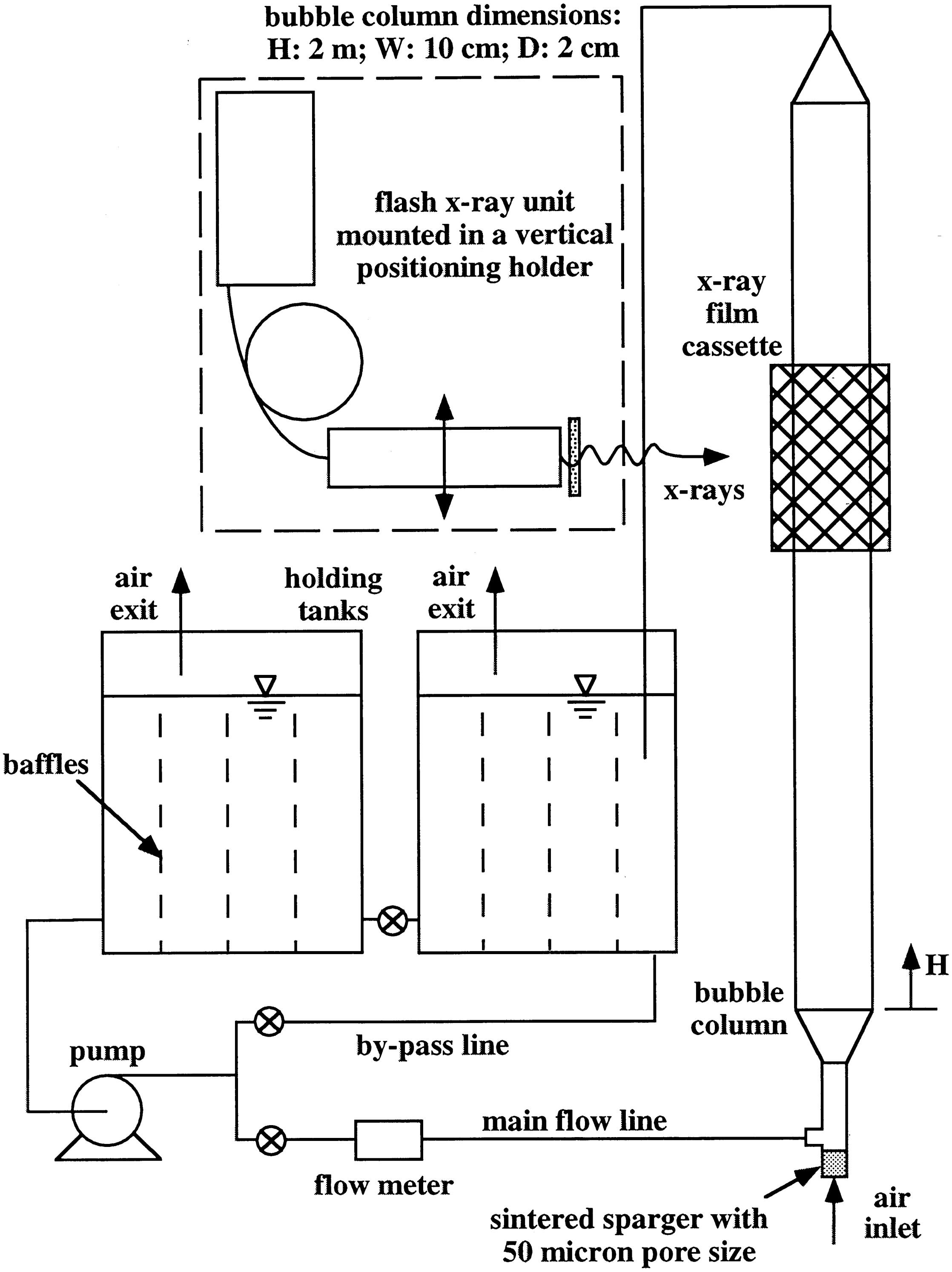

Figure 1: Schematic of the experimental setup.

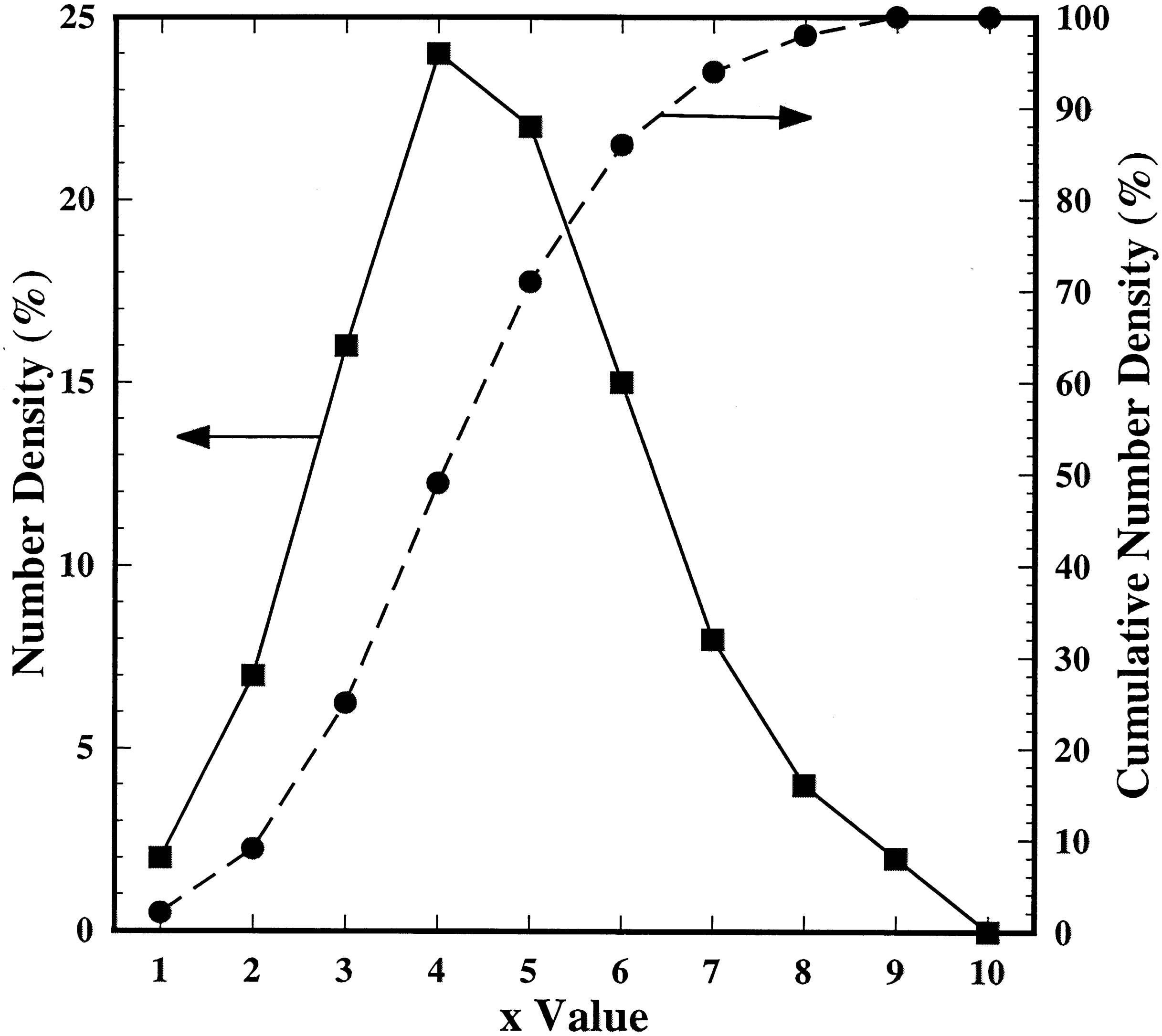

Figure 2: Number density and cumulative number density example plots from the generic data in Table 1.

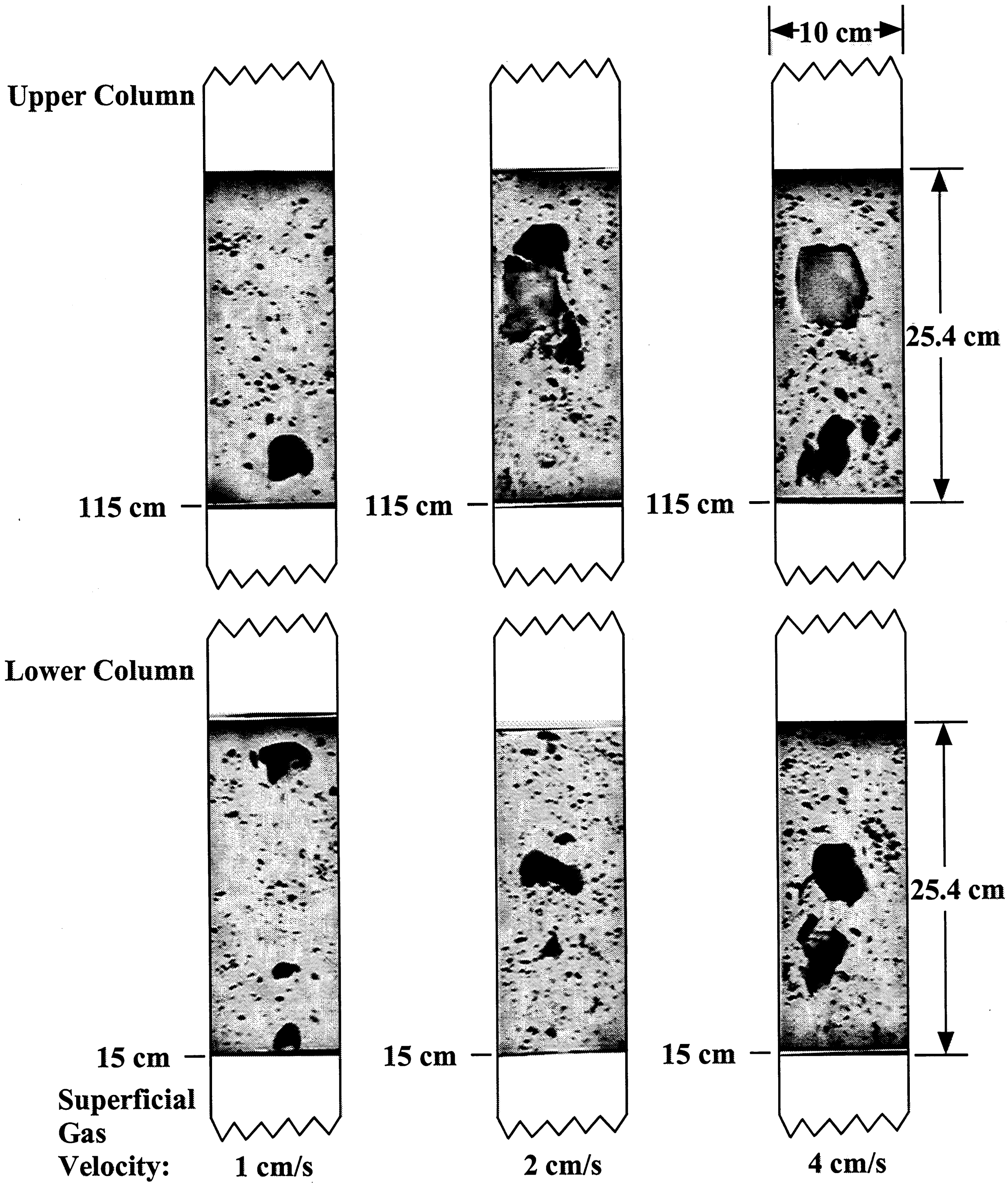

Figure 3: FXR image of the air/water system at different superficial gas velocities and column heights.

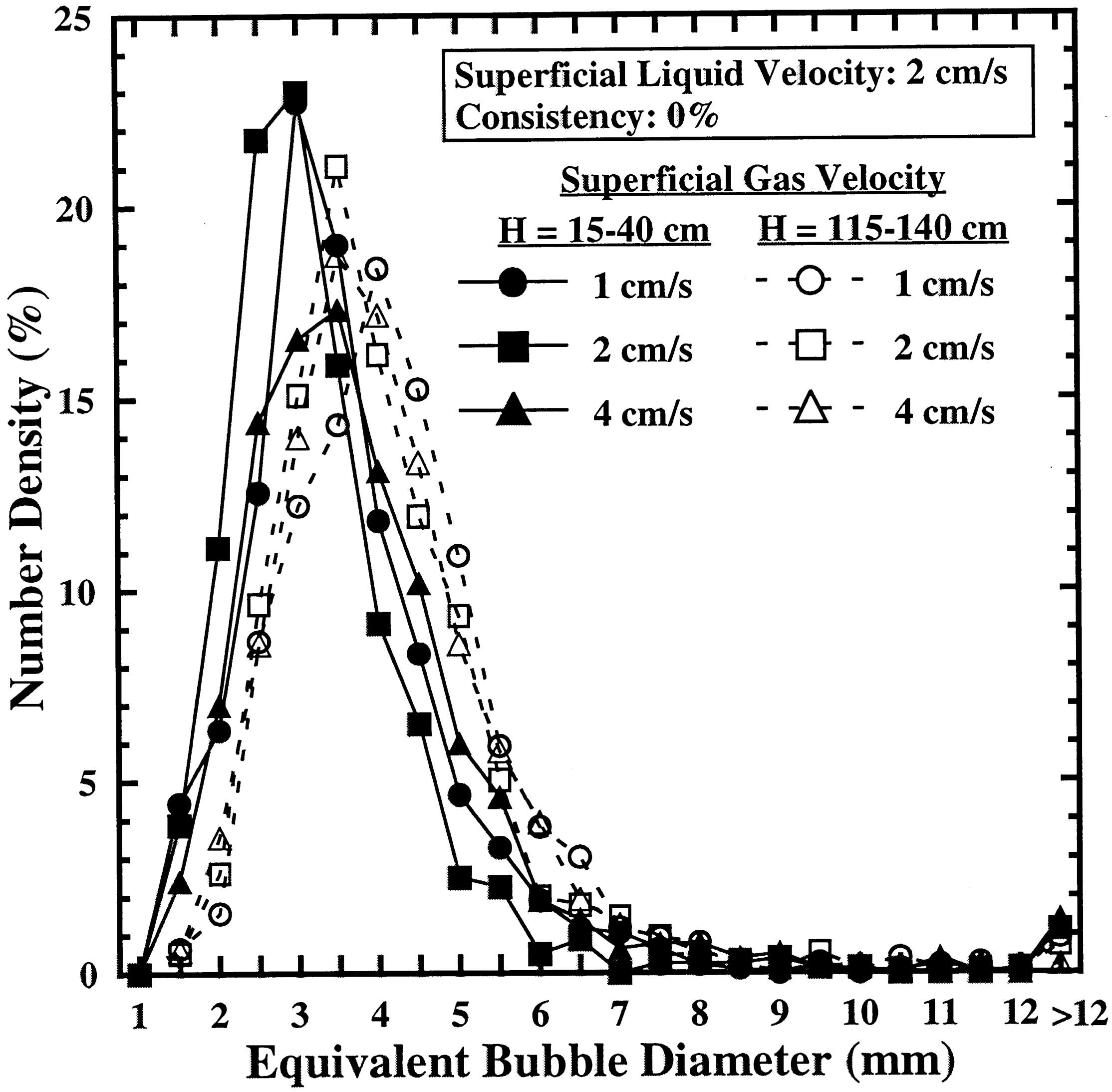

Figure 4: Bubble size number density distributions for all air/water data obtained in this study.

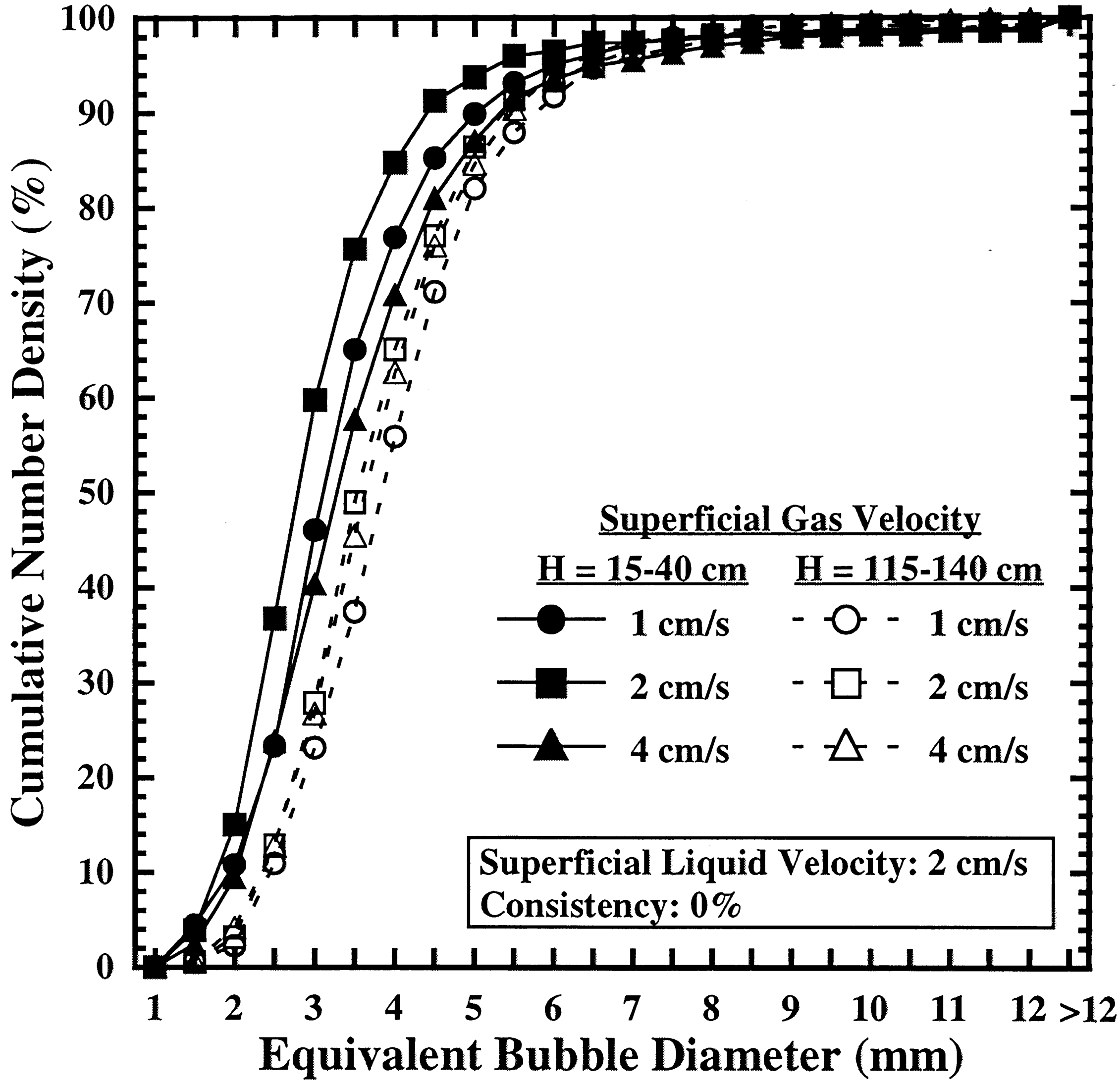

Figure 5: Bubble size cumulative number density distributions for all air/water data obtained in this study.

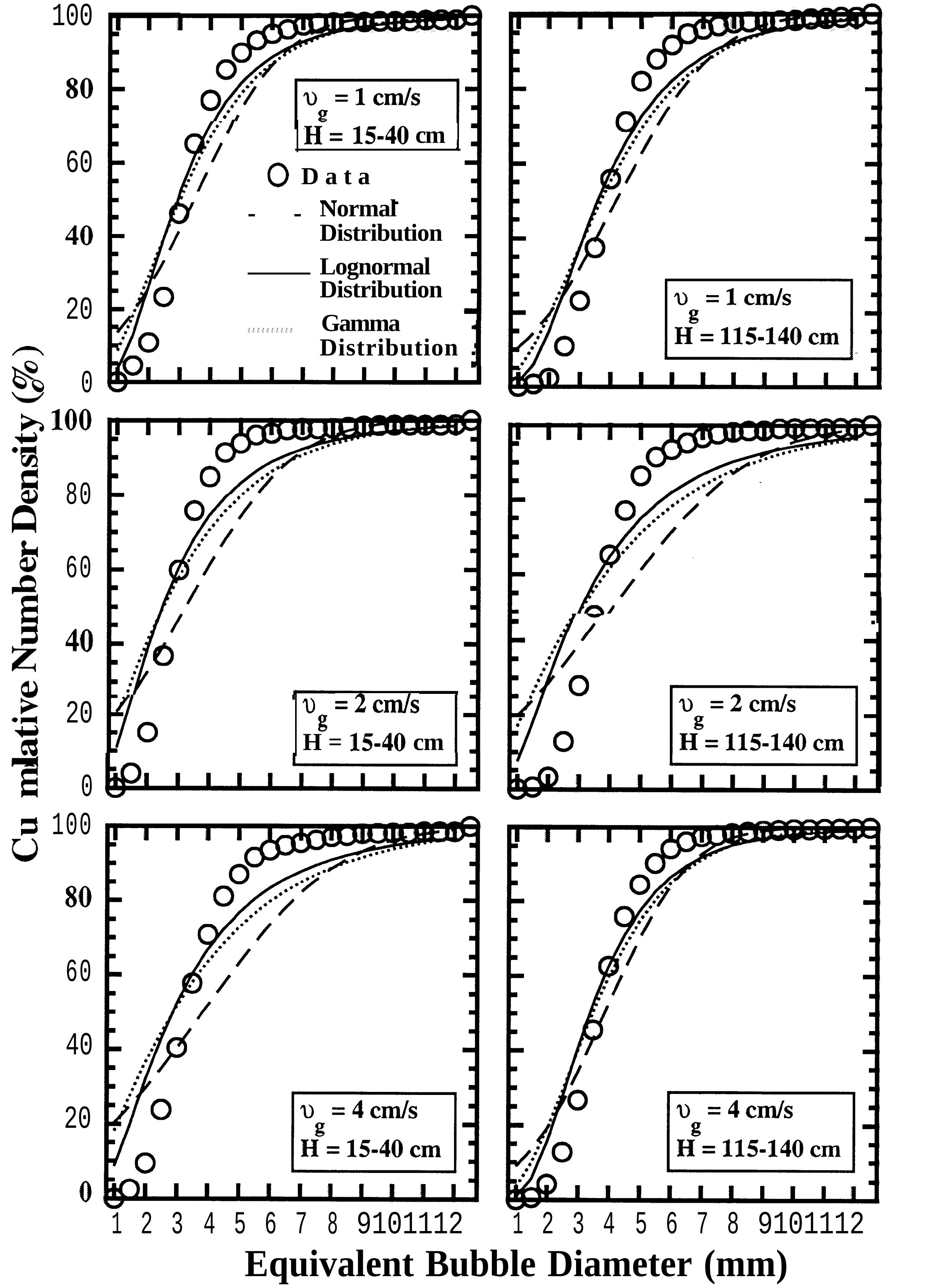

Figure 6: **Normal,** lognormal, and gamma distribution curve fits to all air/water data obtained in this study. Each plot represents a different superficial gas velocity and column height condition.

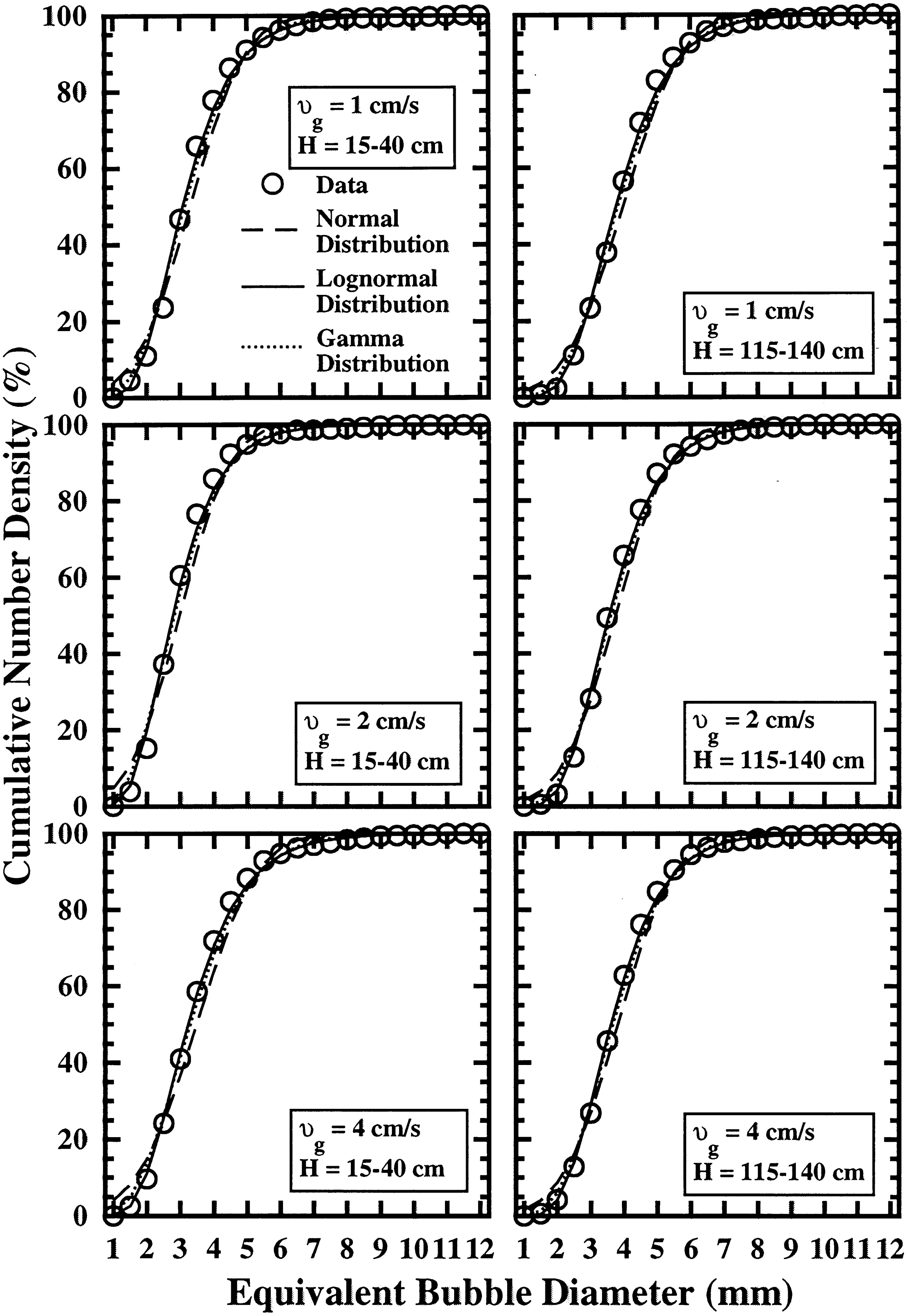

Figure 7: Normal, lognormal, and gamma distribution curve fits to the air/water data with $d \leq 12$ mm. Each plot represents a different superficial gas velocity and column height condition.

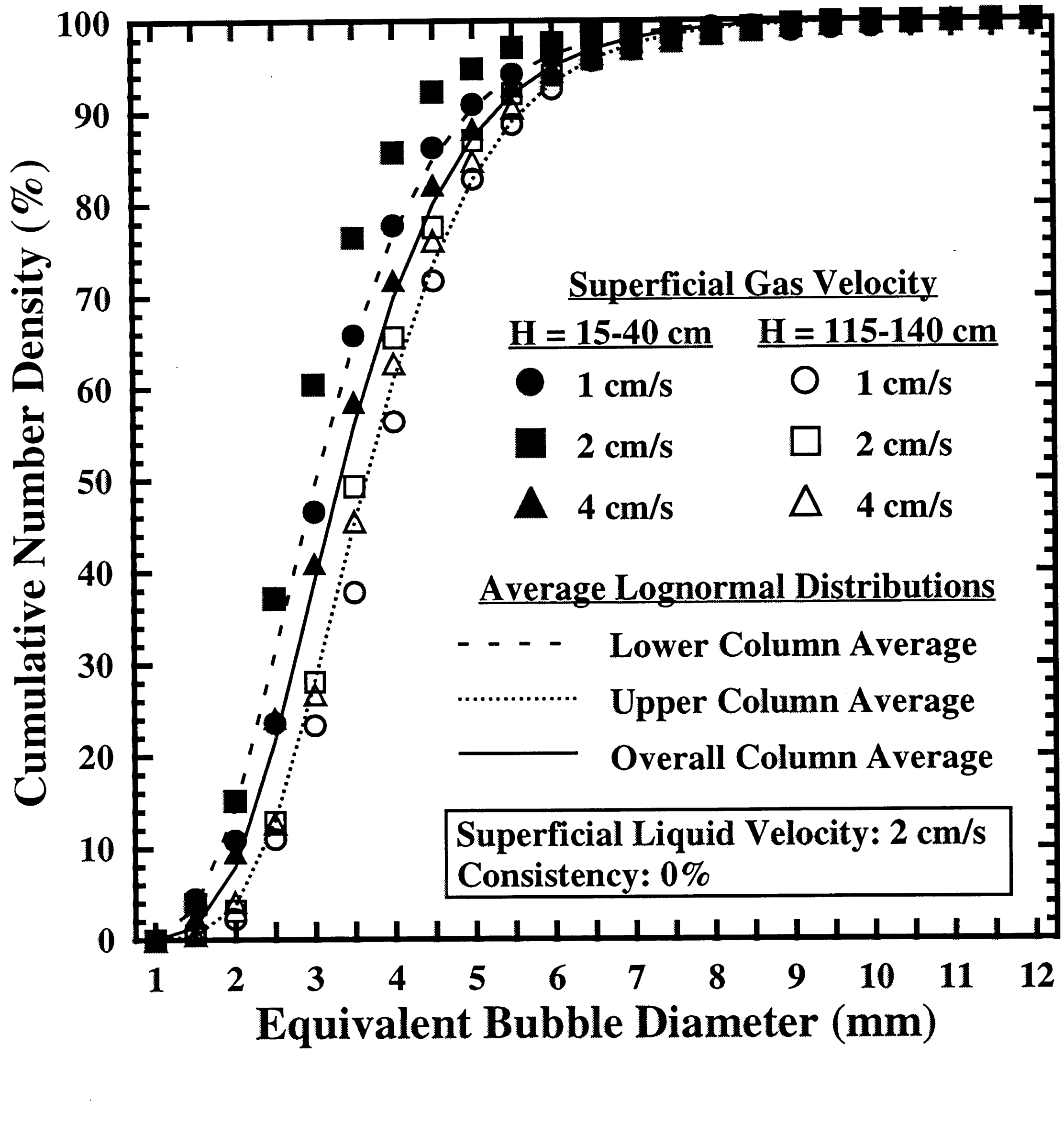

Figure 8: Average lognormal distribution comparisons to the air/water data with d ≤ 12 mm.

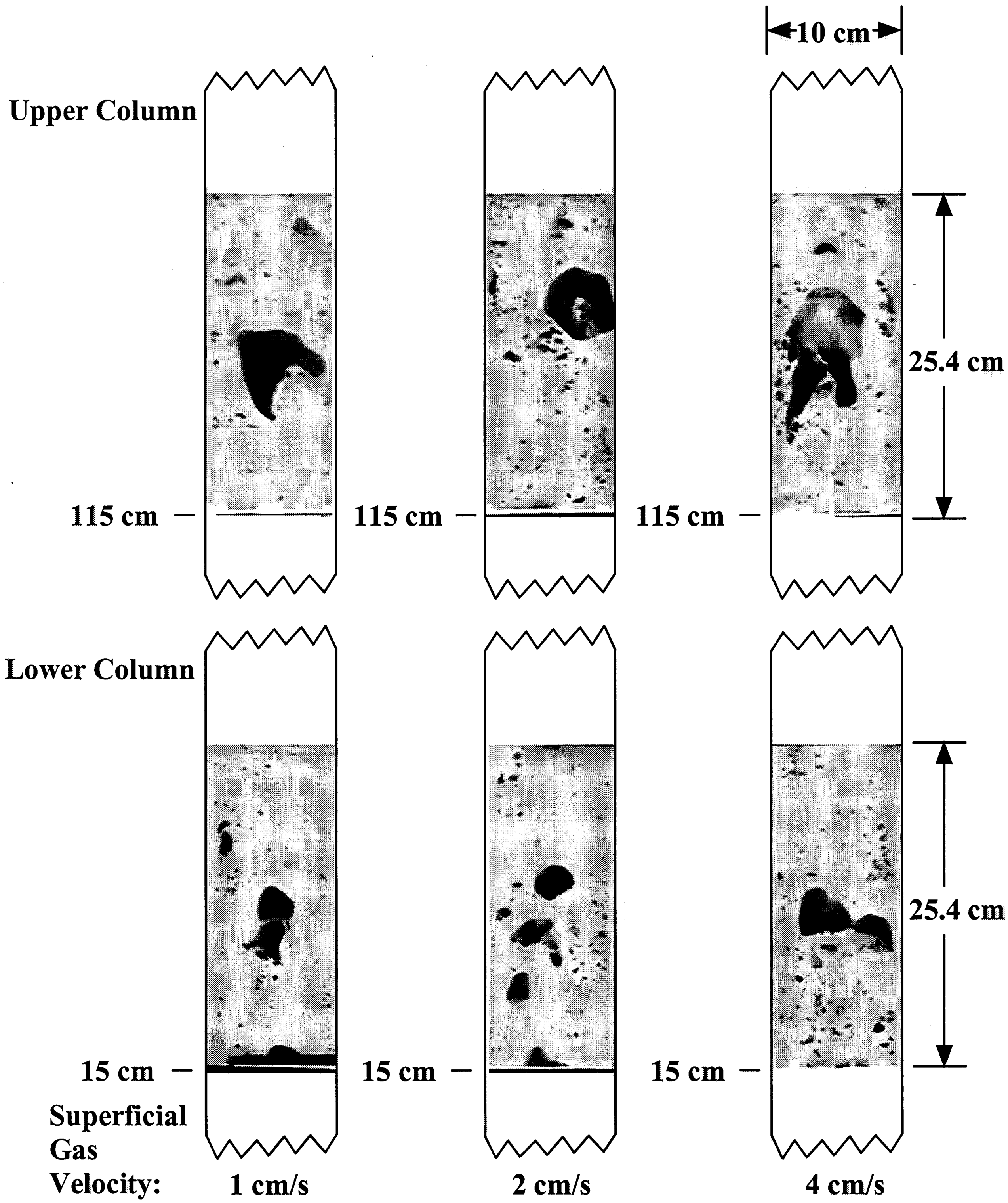

Figure 9: FXR image of the air/water/0.5% copy paper system at different superficial gas velocities and column heights.

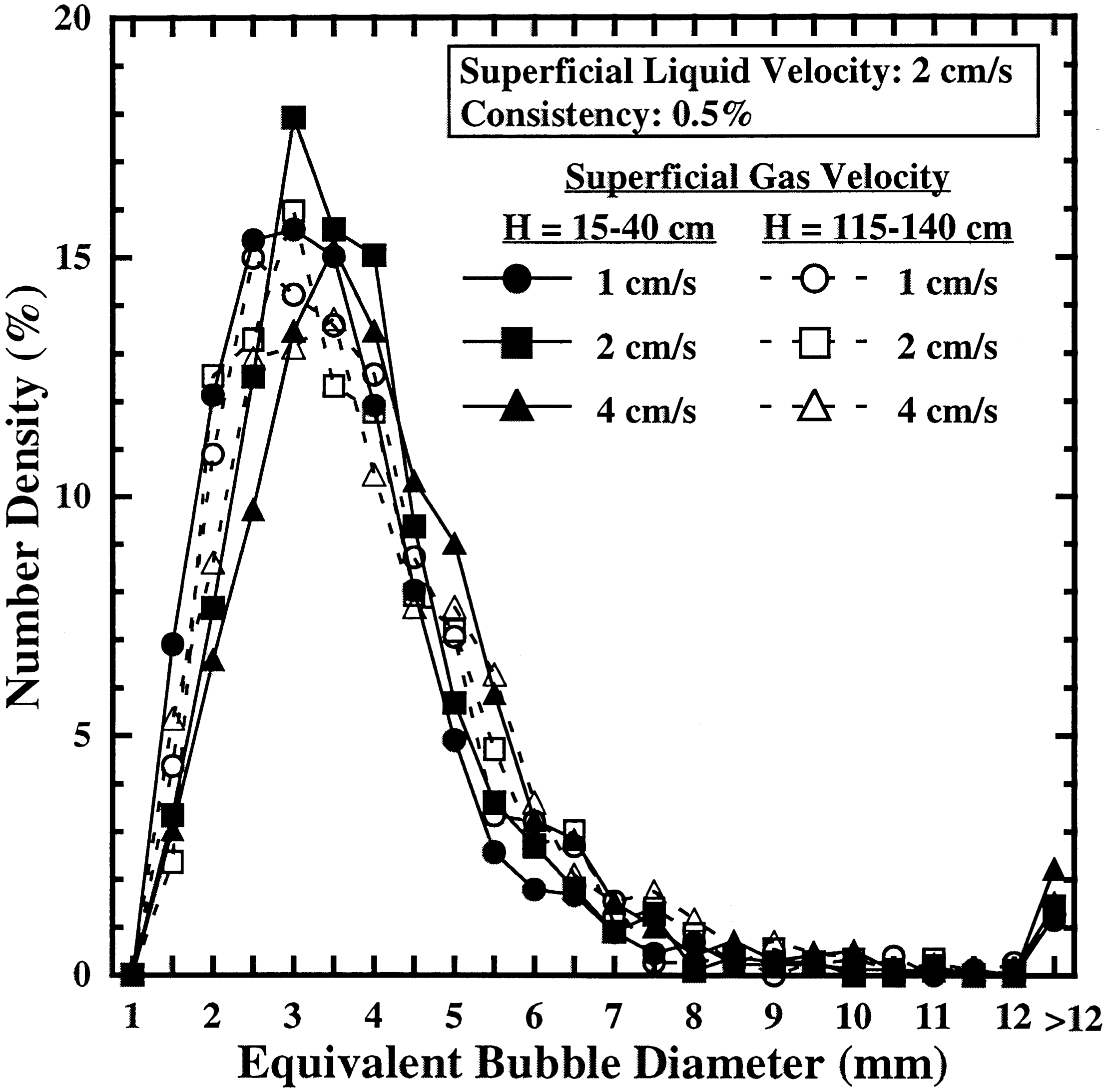

Figure 10: Bubble size number density distributions for all air/water/0.5% copy paper data obtained in this study.

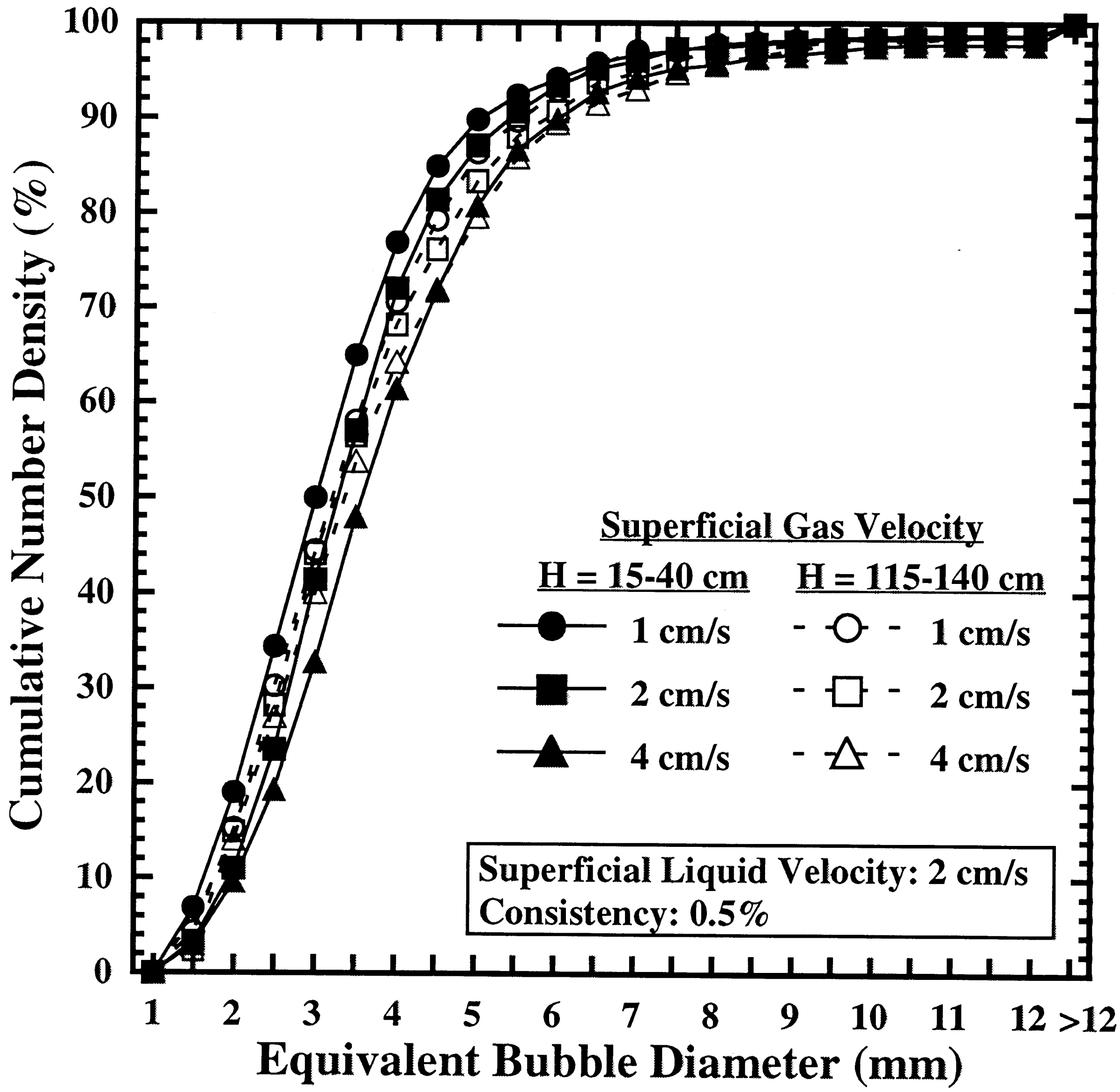

Figure 11: Bubble size cumulative number density distributions for all air/water/0.5% copy paper data obtained in this study.

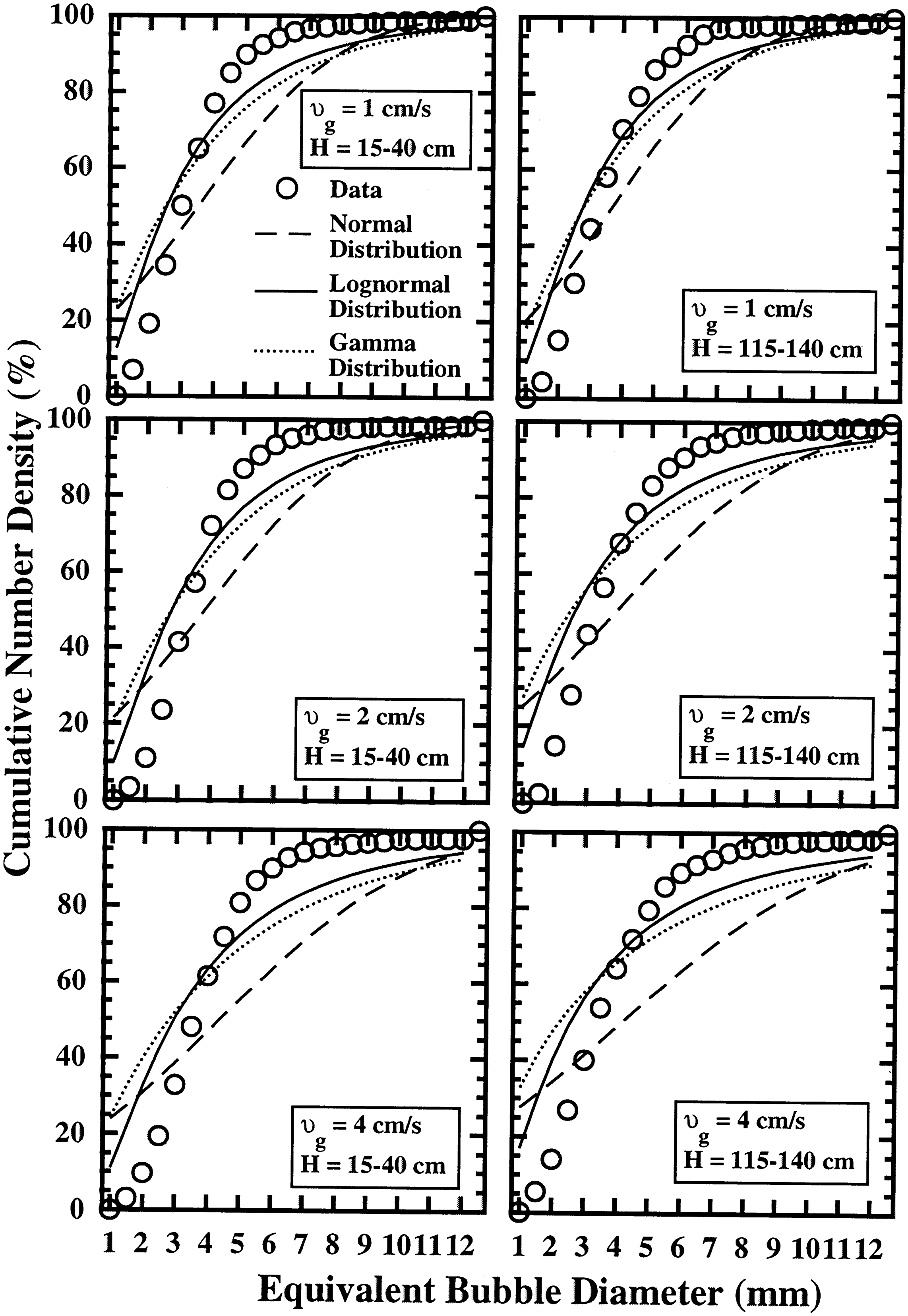

Figure 12: Normal, lognormal, and gamma distribution curve fits to all air/water/0.5% copy paper data obtained in this study. Each plot represents a different superficial gas velocity and column height condition.

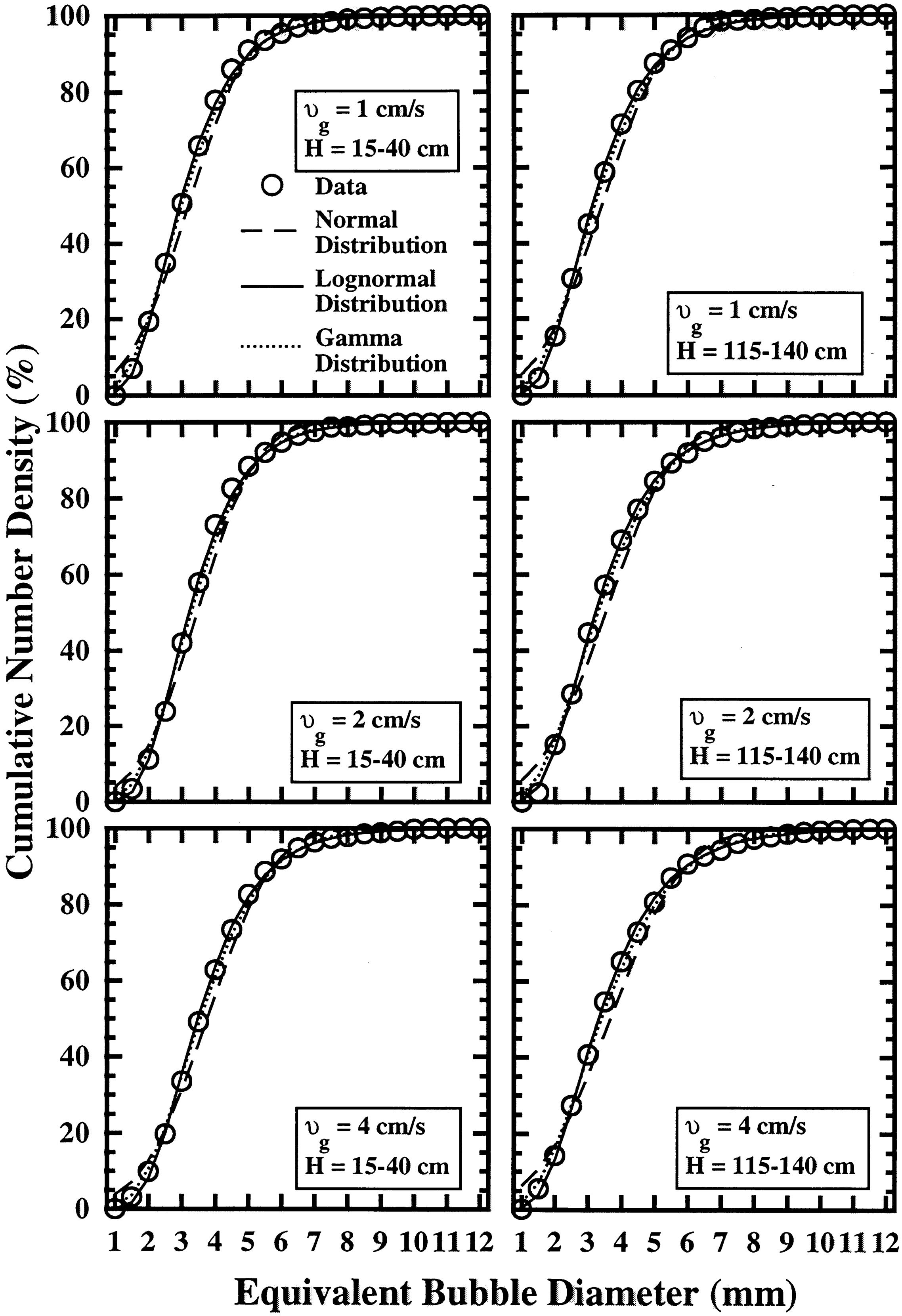

Figure 13: Normal, lognormal, and gamma distribution curve fits to the air/water/0.5% copy paper data with d ≤ 12 mm. Each plot represents a different superficial gas velocity and column height condition.

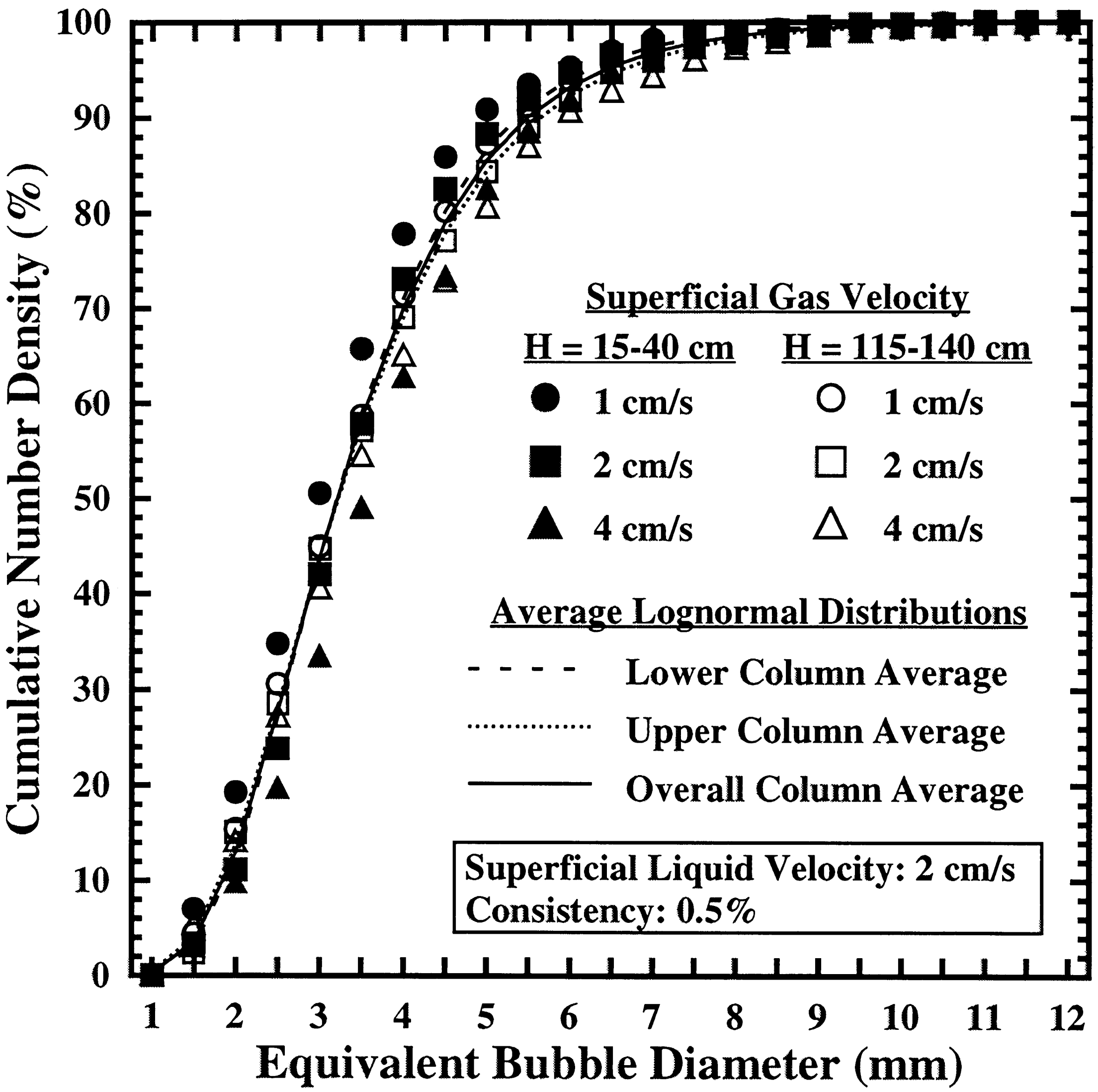

Figure 14: Average lognormal distribution comparisons to the air/water/0.5% copy paper data with $d \leq 12$ mm.

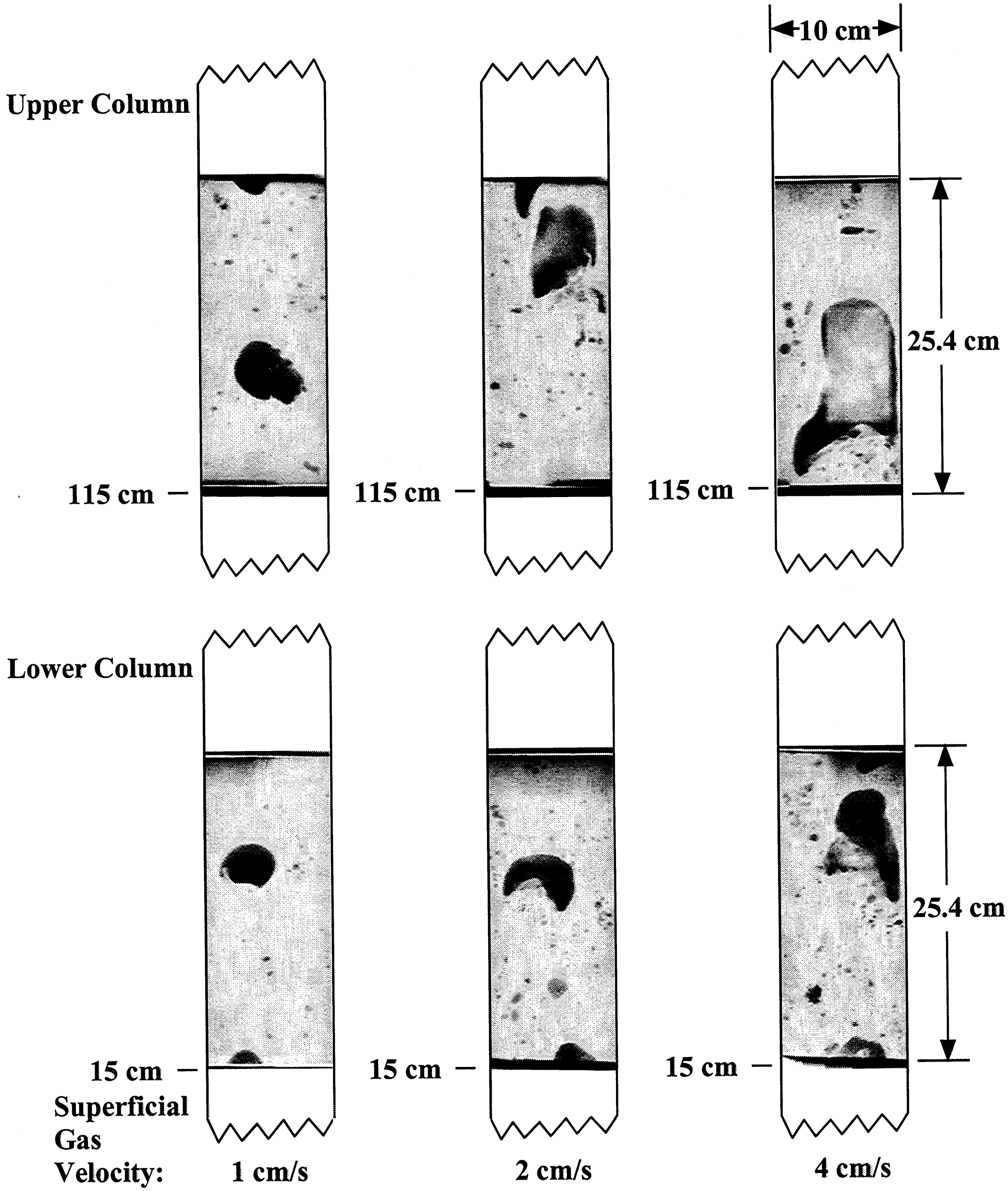

Figure 15: FXR image of the air/water/1% copy paper system at different superficial gas velocities and column heights.

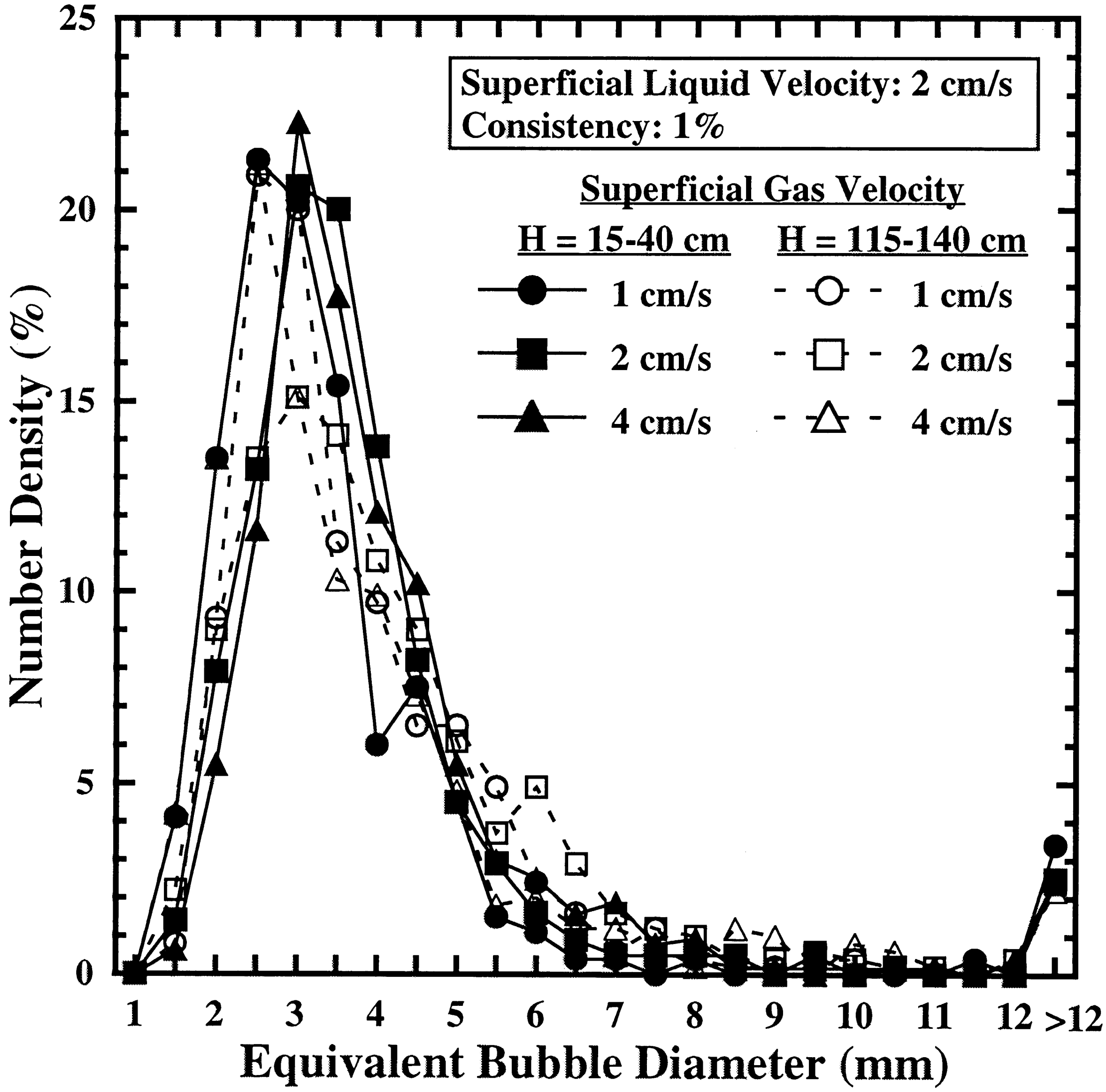

Figure 16: Bubble size number density distributions for all air/water/1% copy paper data obtained in this study.

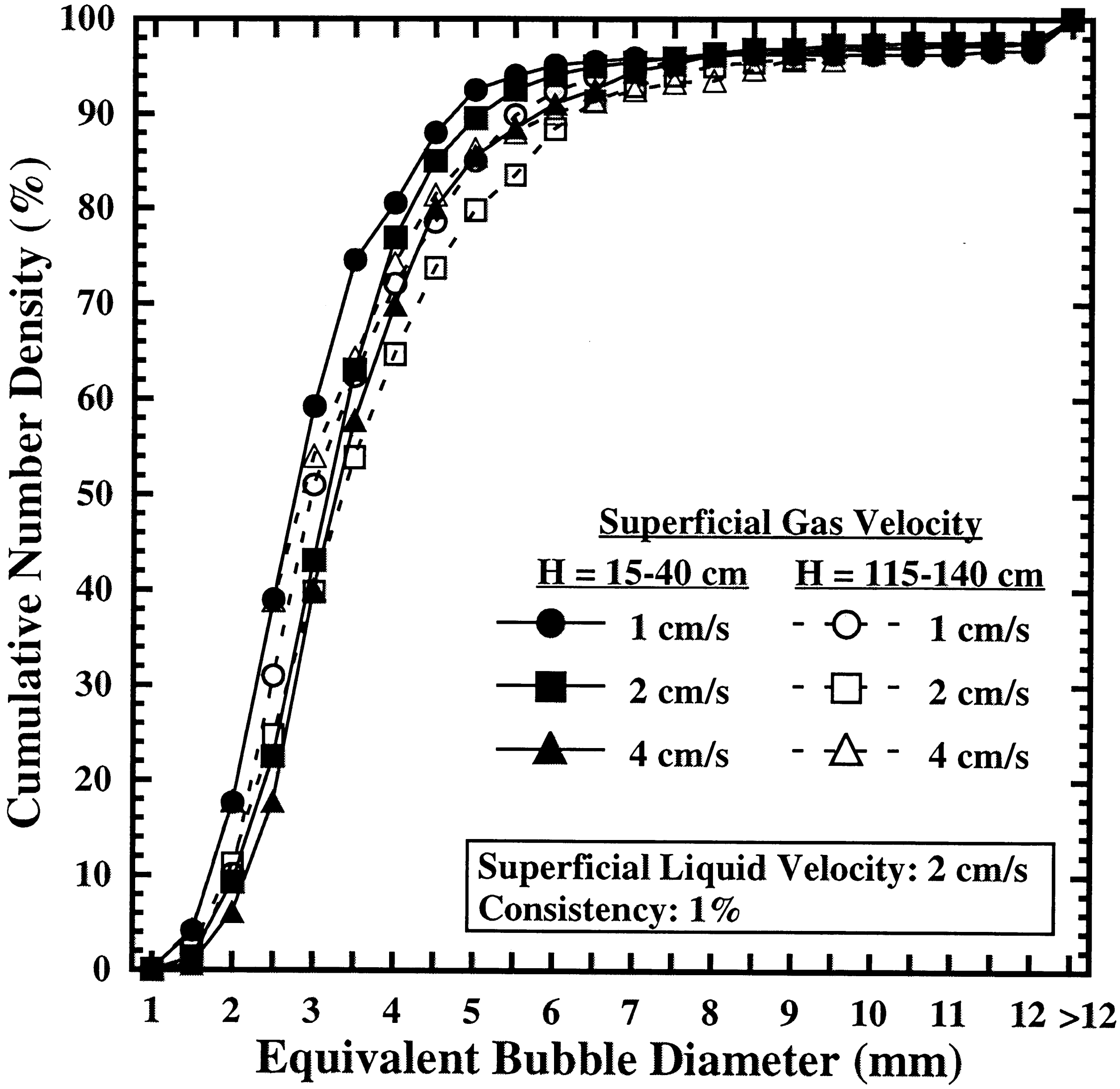

Figure 17: Bubble size cumulative number density distributions for all air/water/1% copy paper data obtained in this study.

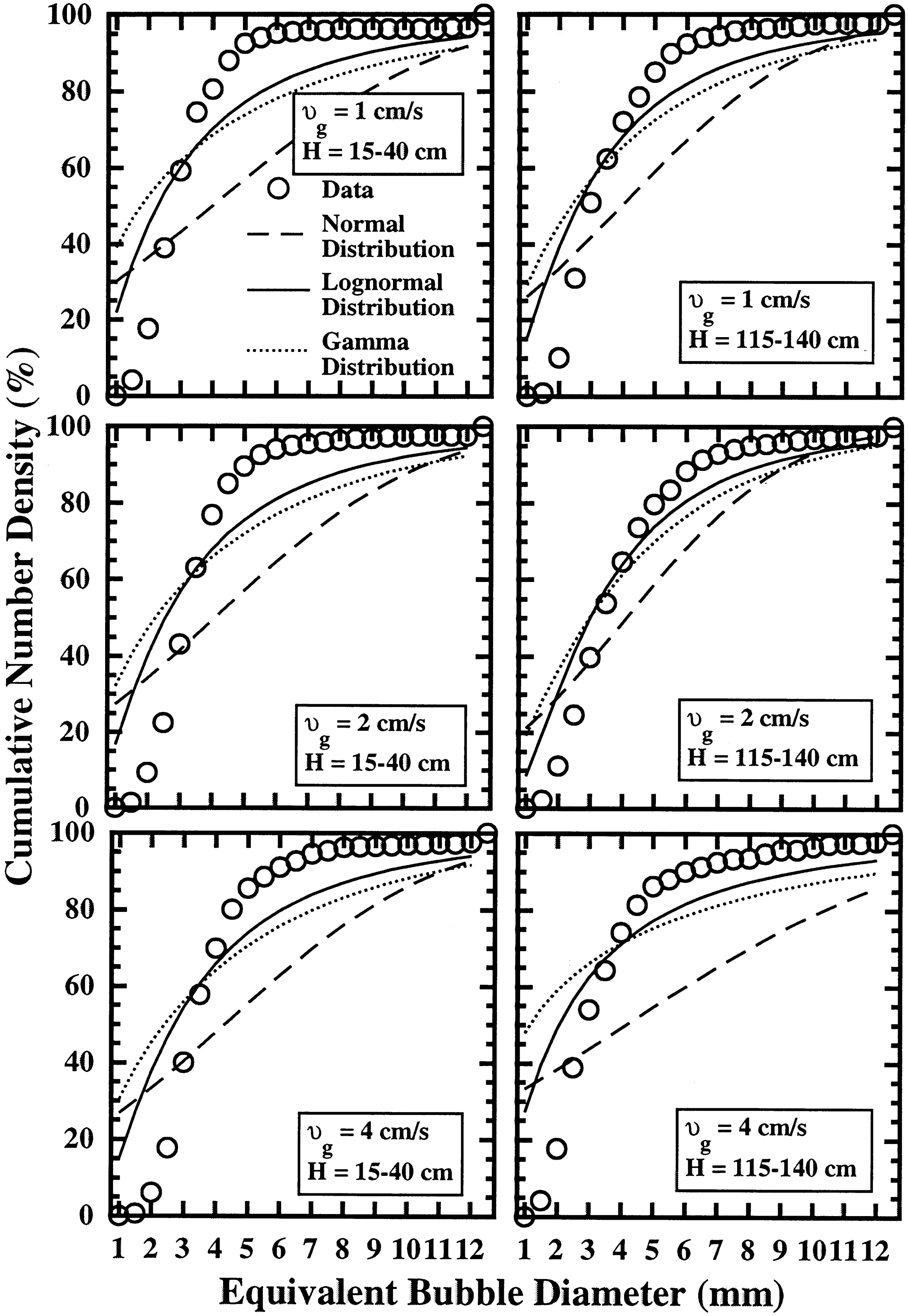

Figure 18: Normal, lognormal, and gamma distribution curve fits to all air/water/1% copy paper data obtained in this study. Each plot represents a different superficial gas velocity and column height condition.

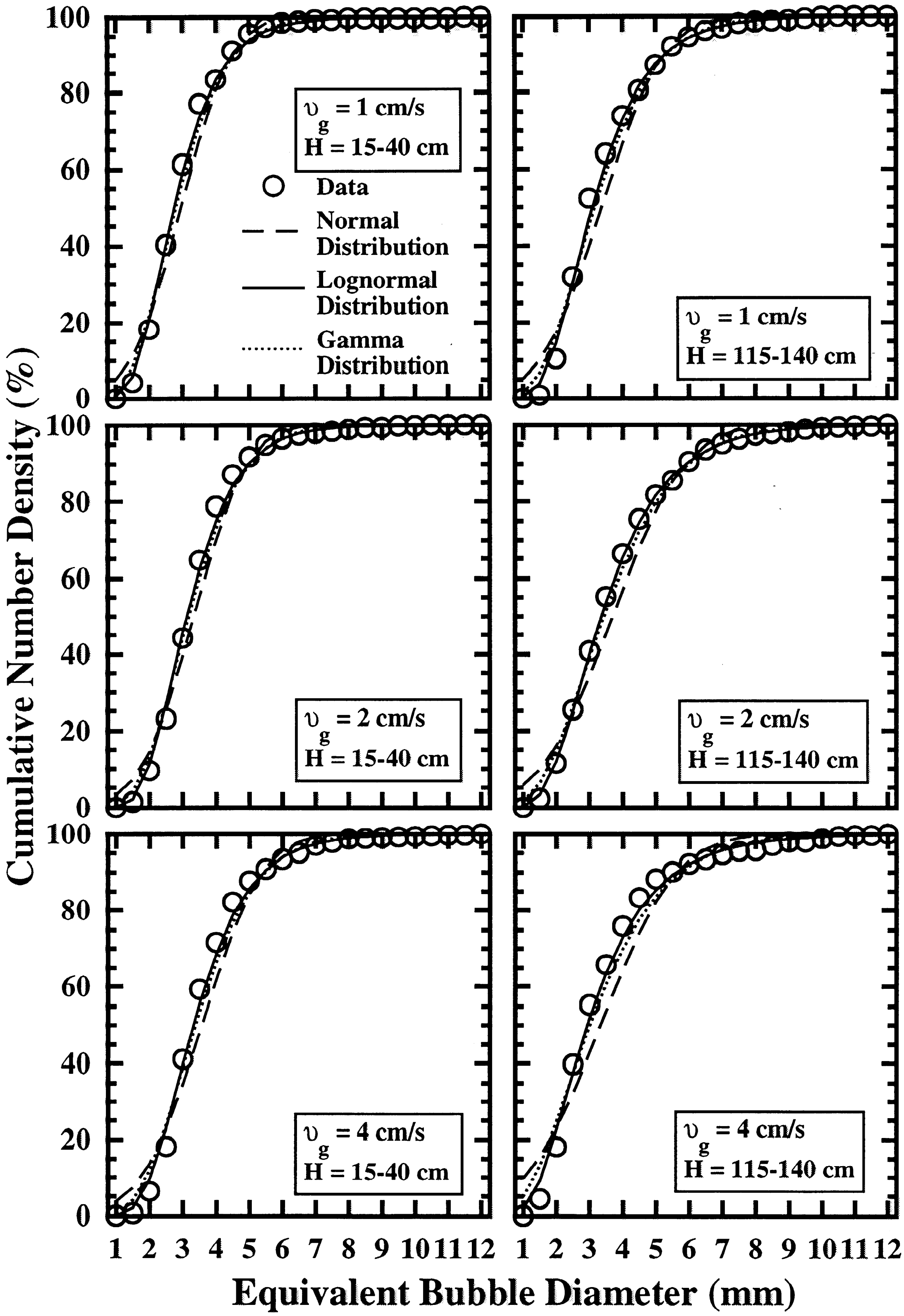

Figure 19: Normal, lognormal, and gamma distribution curve fits to the air/water/1% copy paper data with d ≤ 12 mm. Each plot represents a different superficial gas velocity and column height condition.

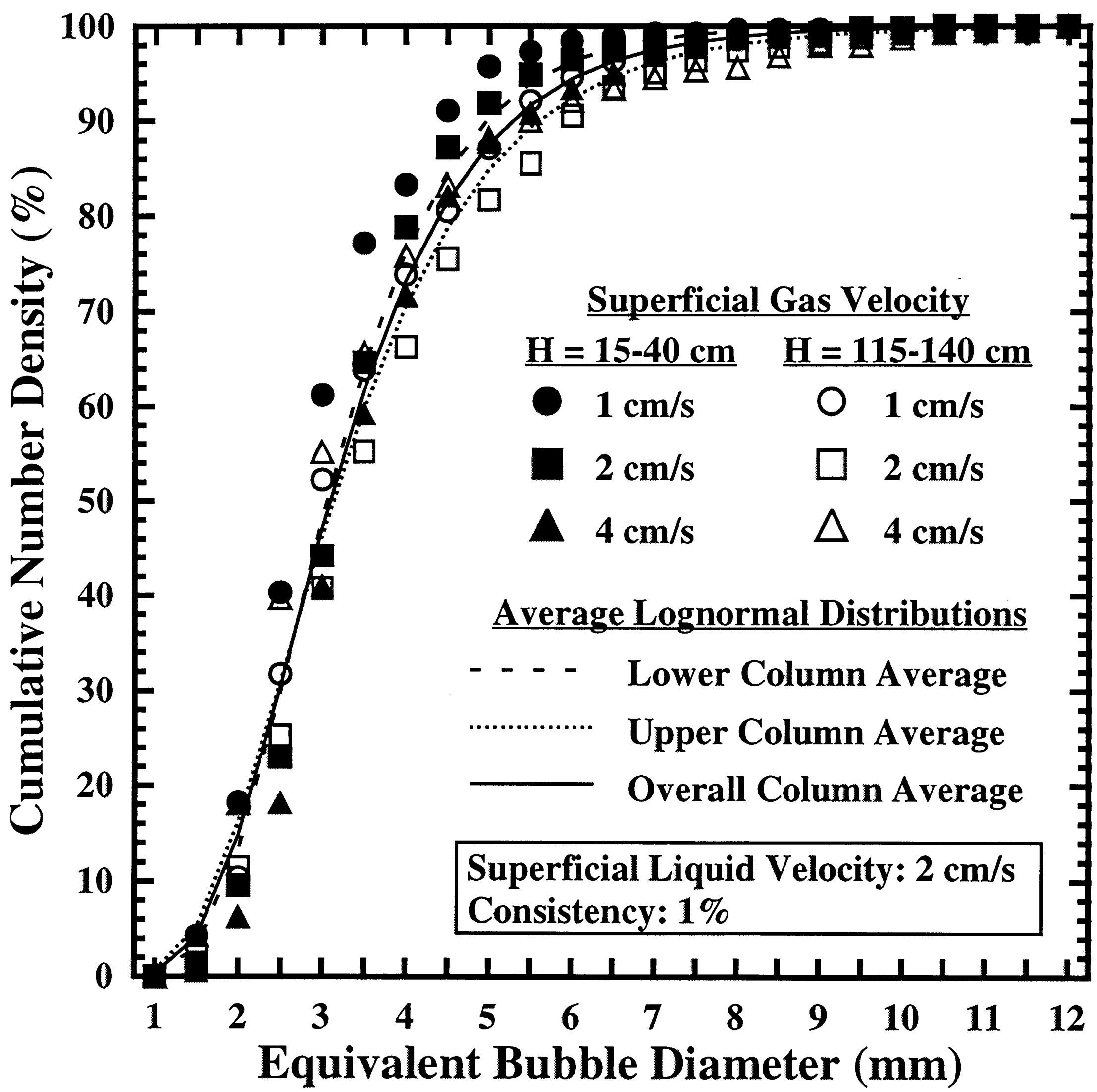

Figure 20: Average lognormal distribution comparisons to the air/water/1% copy paper data with d ≤ 12 mm.

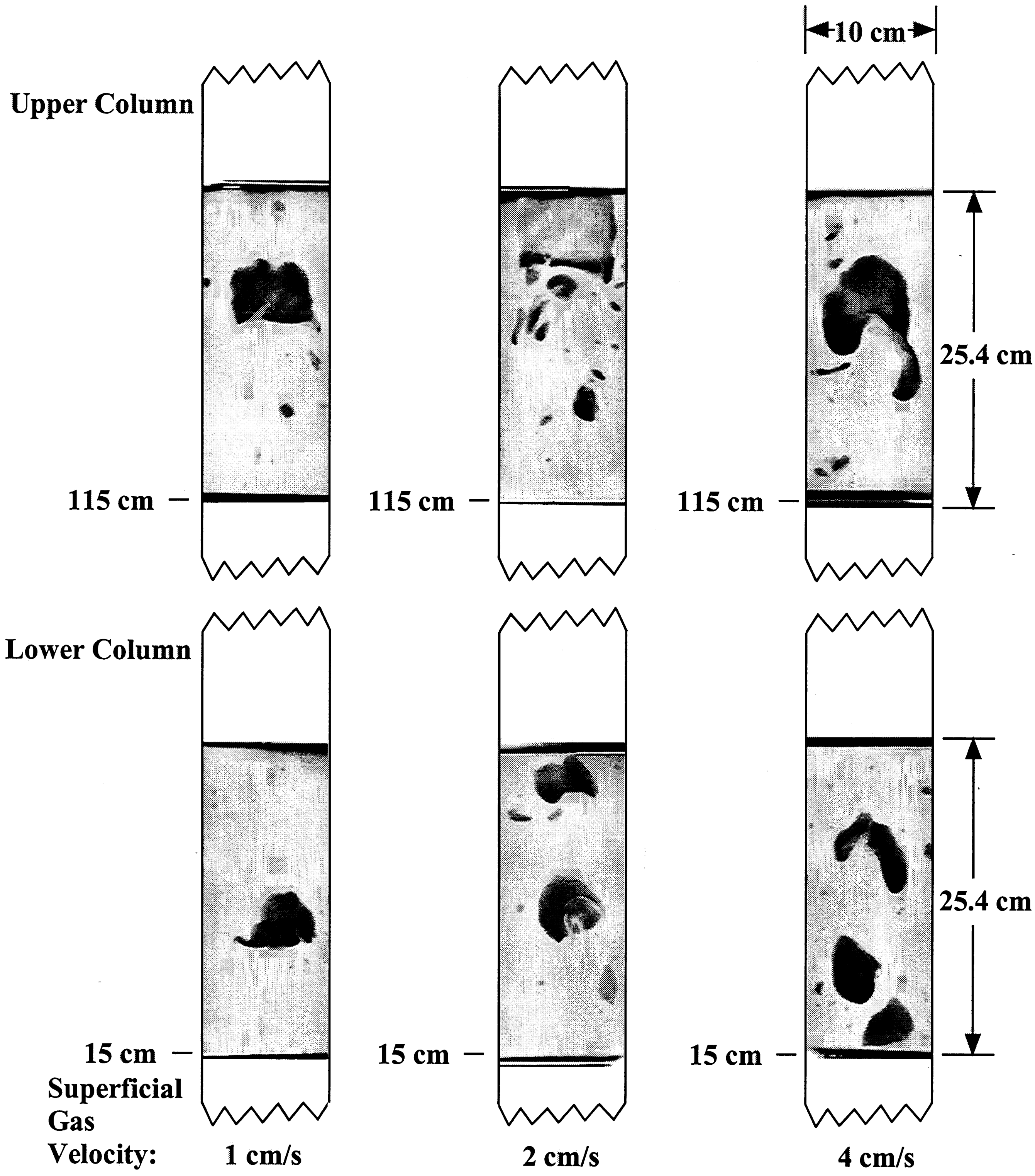

Figure 21: FXR image of the air/water/1.5% copy paper system at different superficial gas velocities and column heights.

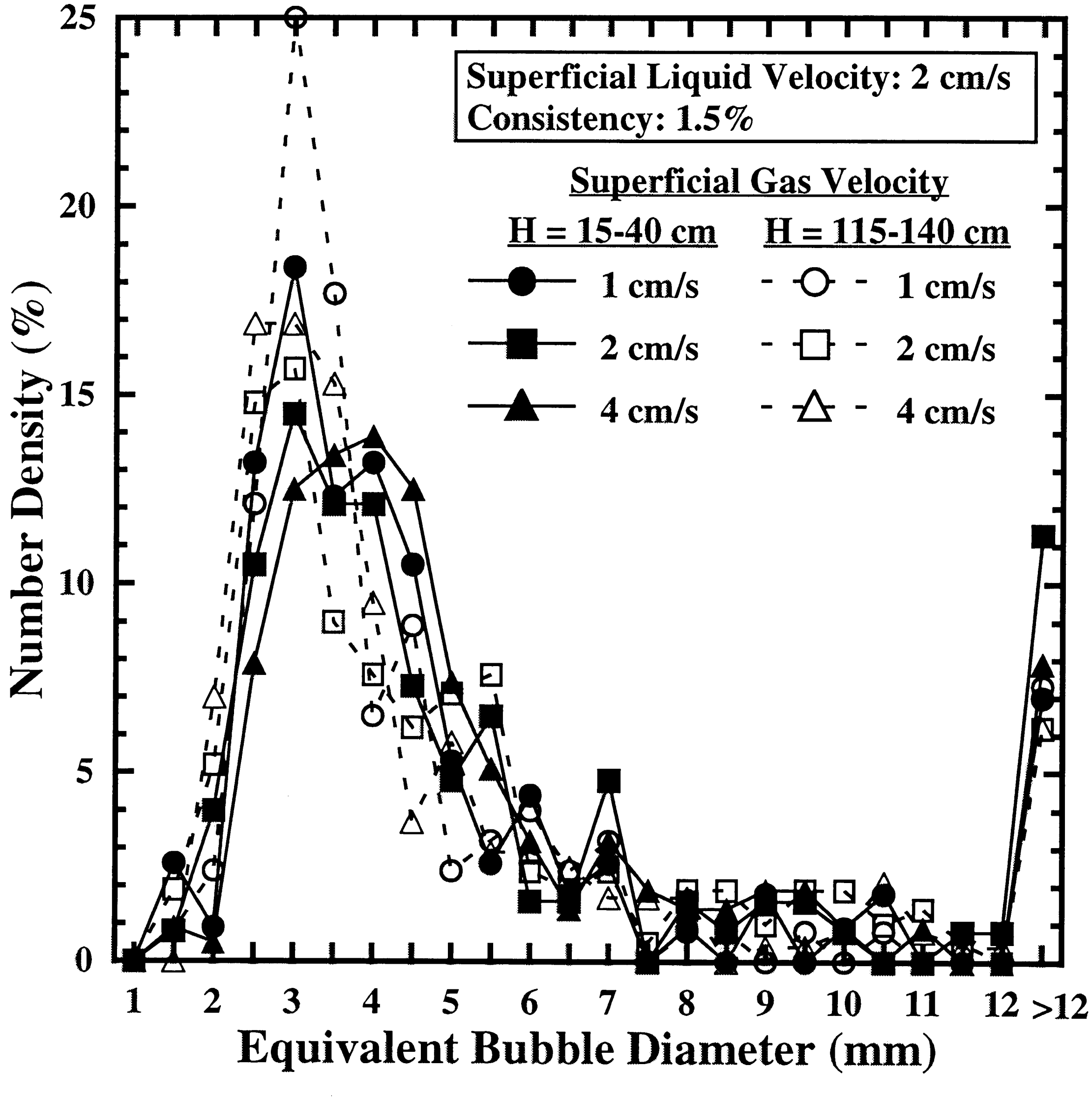

Figure 22: Bubble size number density distributions for all air/water/1.5% copy paper data obtained in this study.

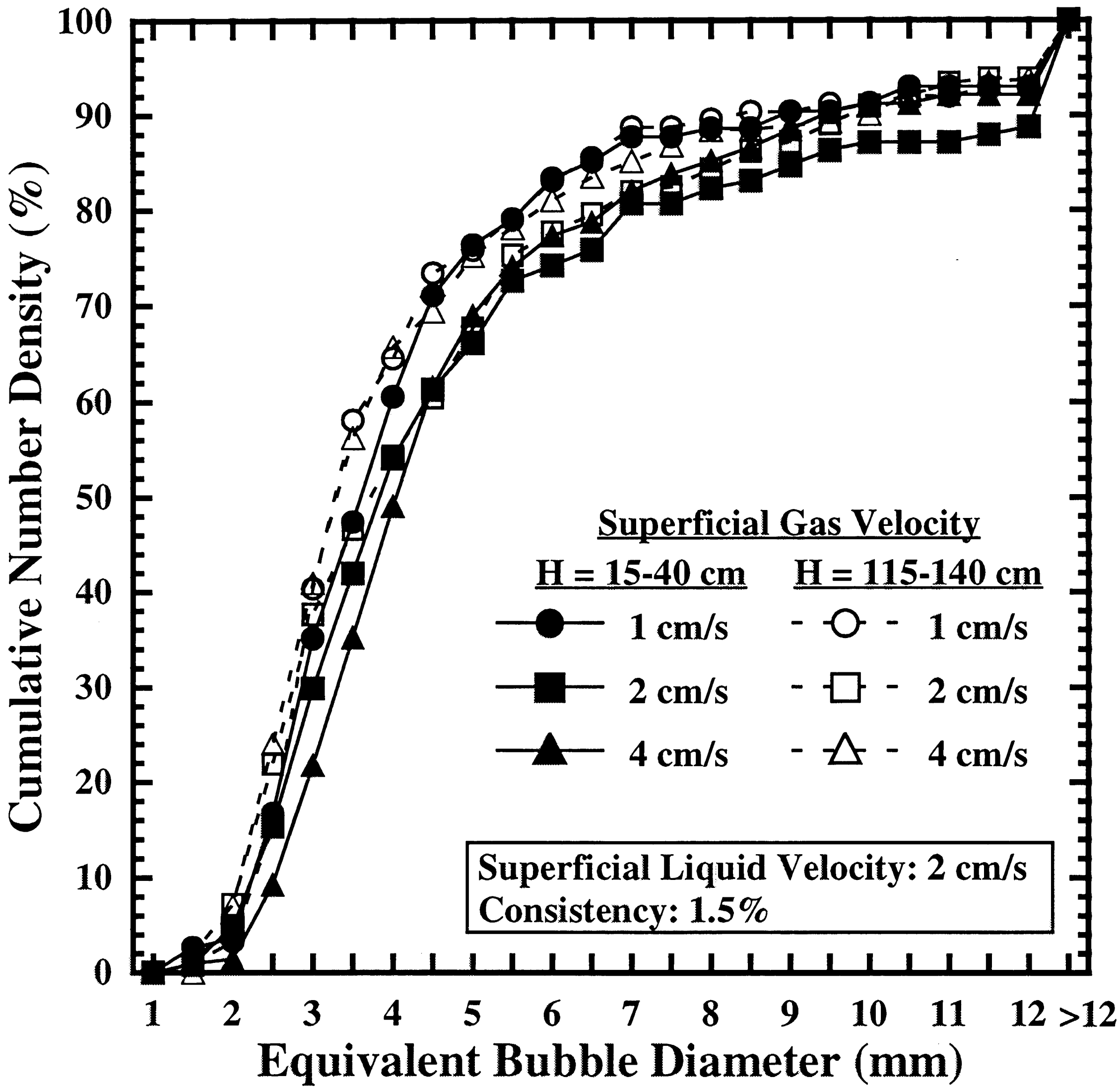

Figure 23: Bubble size cumulative number density distributions for all air/water/1.5% copy paper data obtained in this study.

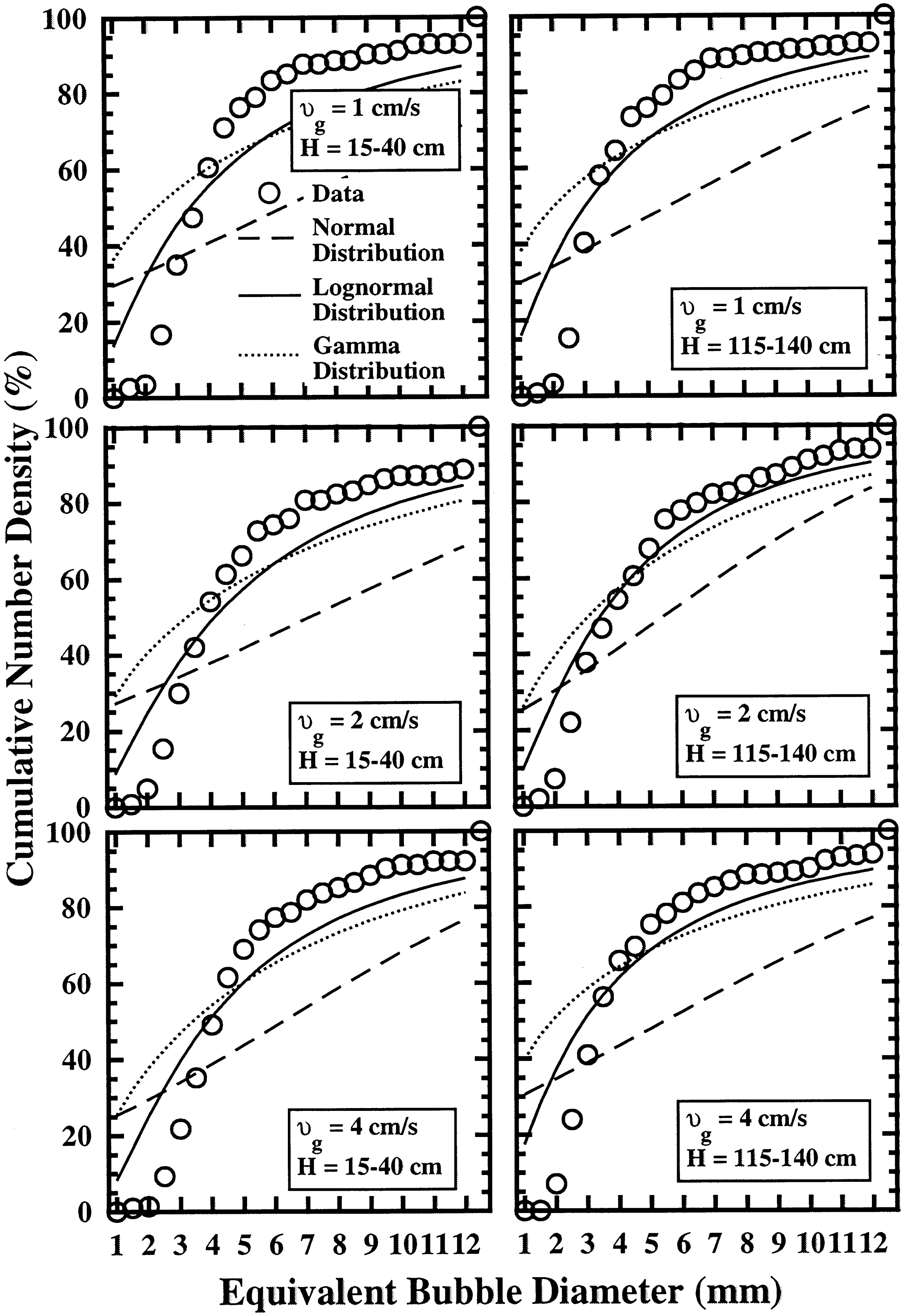

Figure 24: Normal, lognormal, and gamma distribution curve fits to all air/water/1.5% copy paper data obtained in this study. Each plot represents a different superficial gas velocity and column height condition.

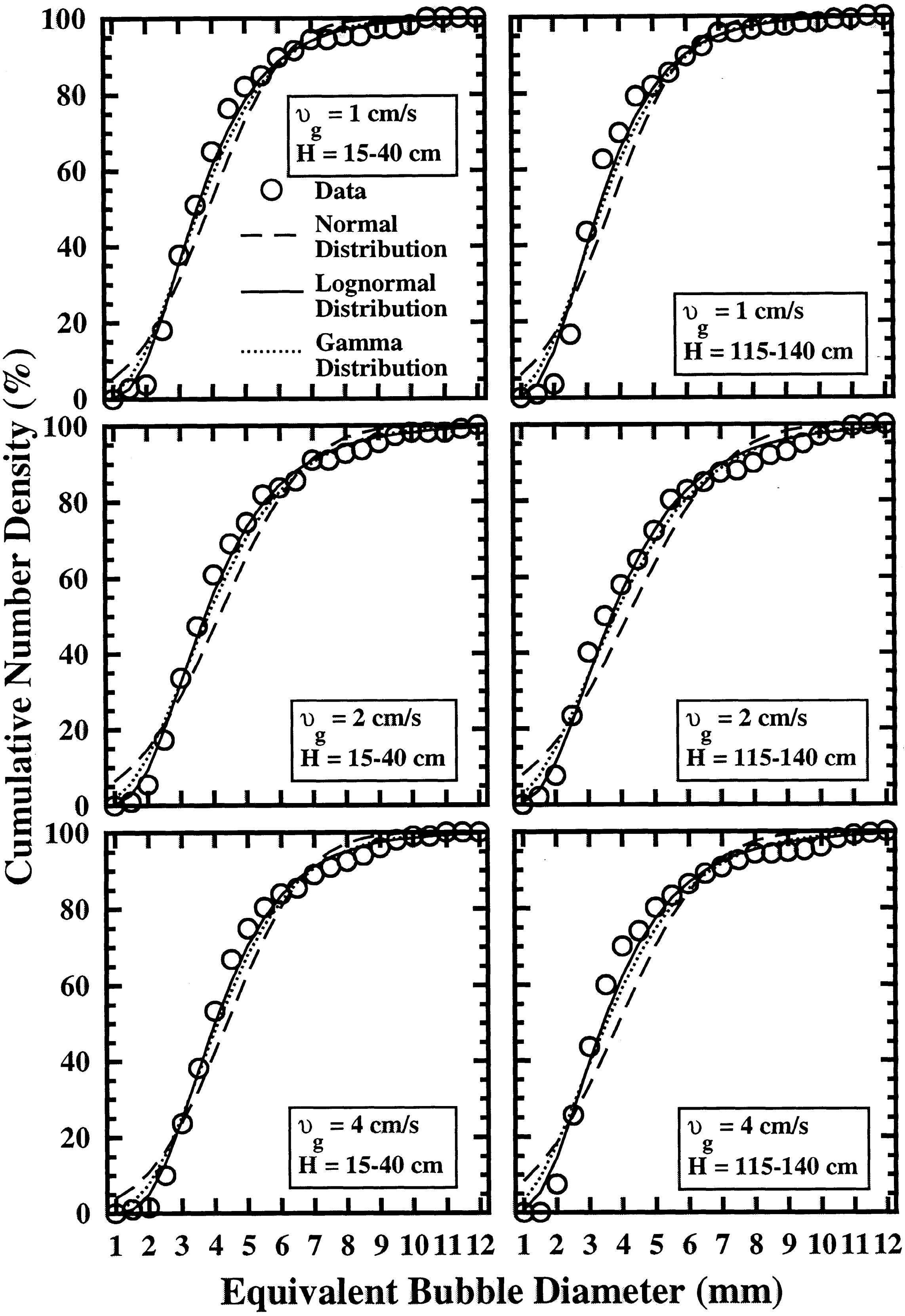

Figure 25: Normal, lognormal, and gamma distribution curve fits to the air/water/1.5% copy paper data with $d \leq 12$ mm. Each plot represents a different superficial gas velocity and column height condition.

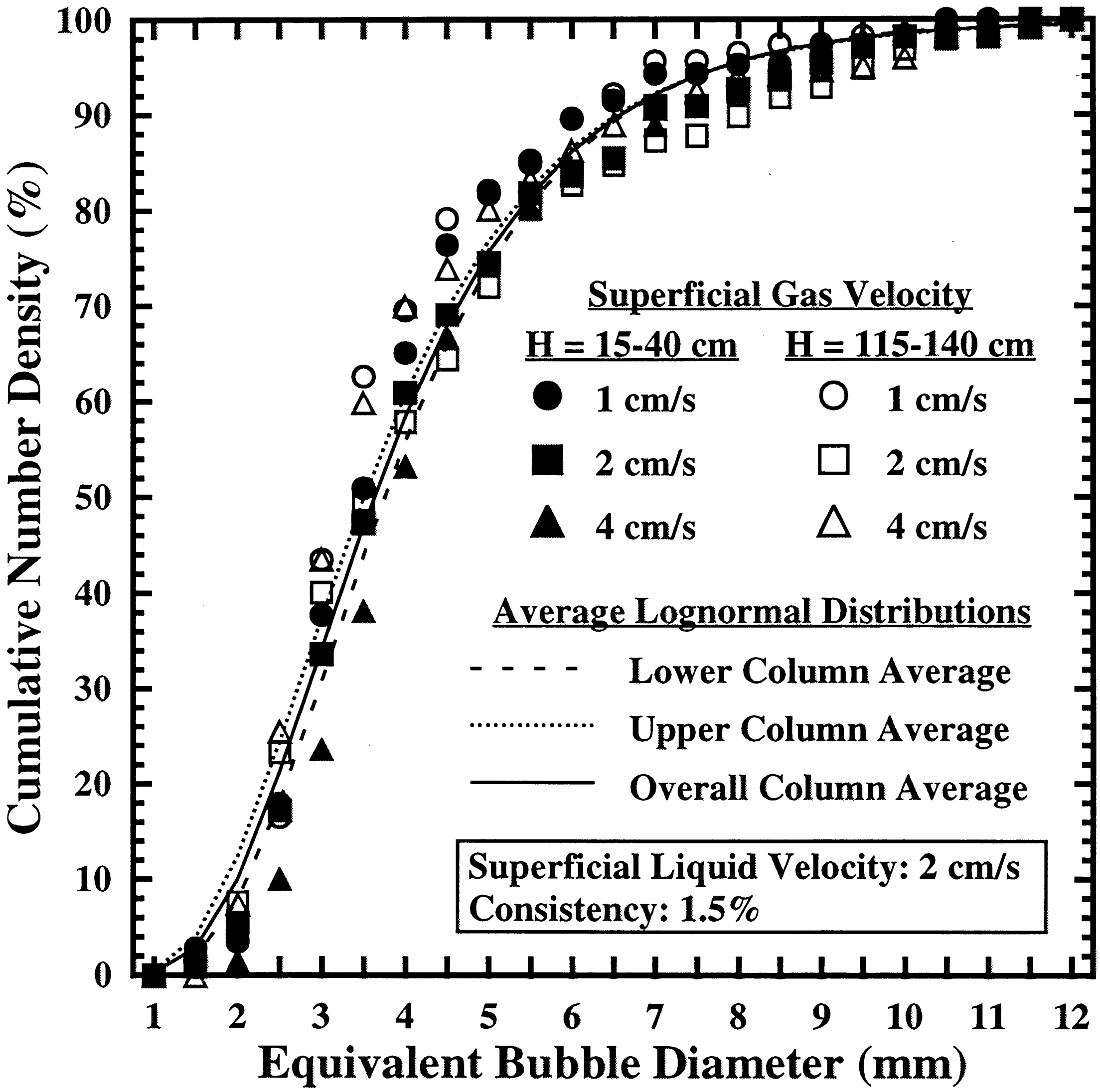

Figure 26: Average lognormal distribution comparisons to the air/water/1.5% copy paper data with $d \leq 12$ mm.

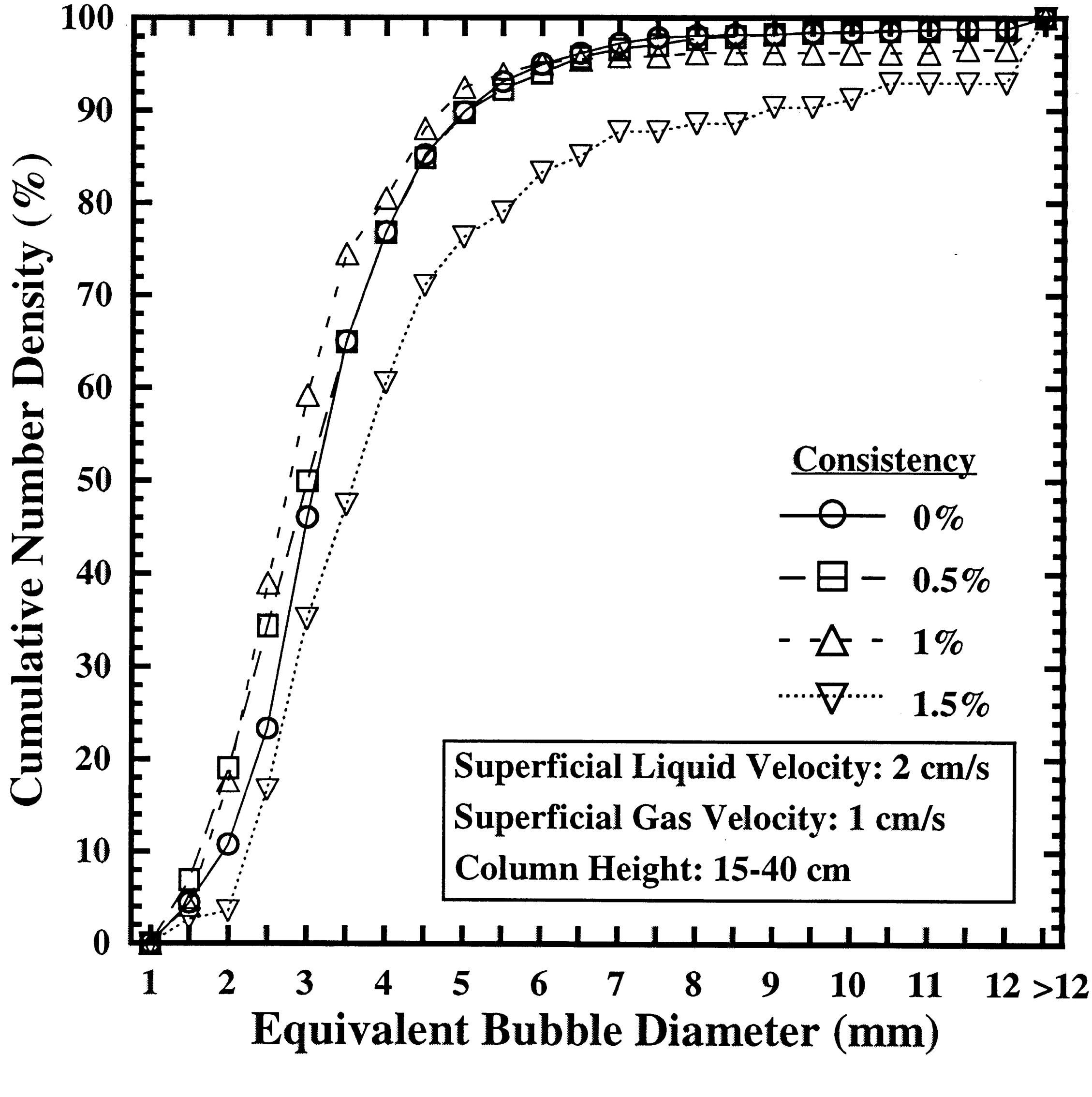

Figure 27: Effect of copy paper consistency on the bubble size cumulative number density for υ_g = 1 cm/s and H = 15-40 cm.

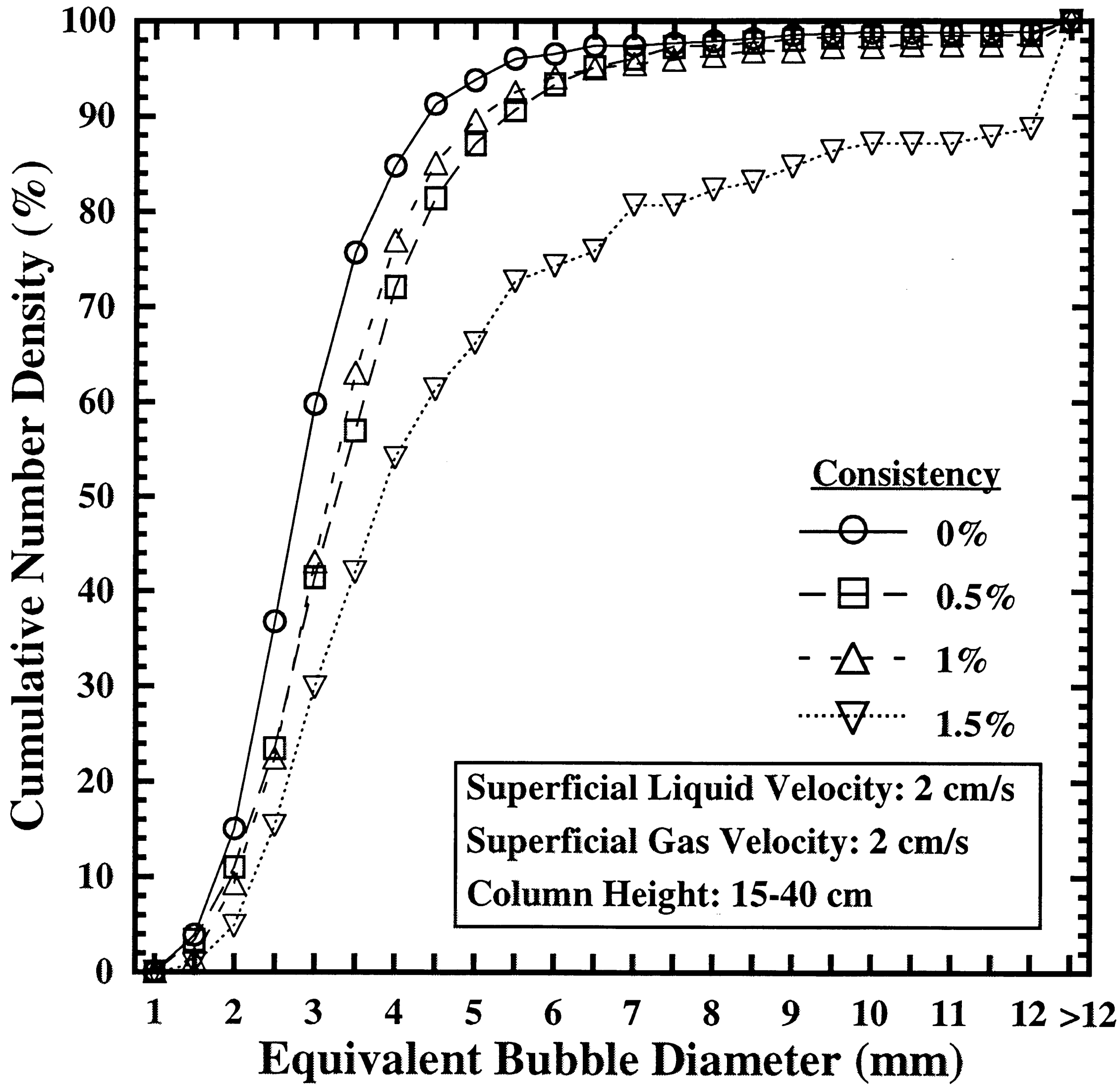

Figure 28: Effect of copy paper consistency on the bubble size cumulative number density for υ_g = 2 cm/s and H = 15-40 cm.

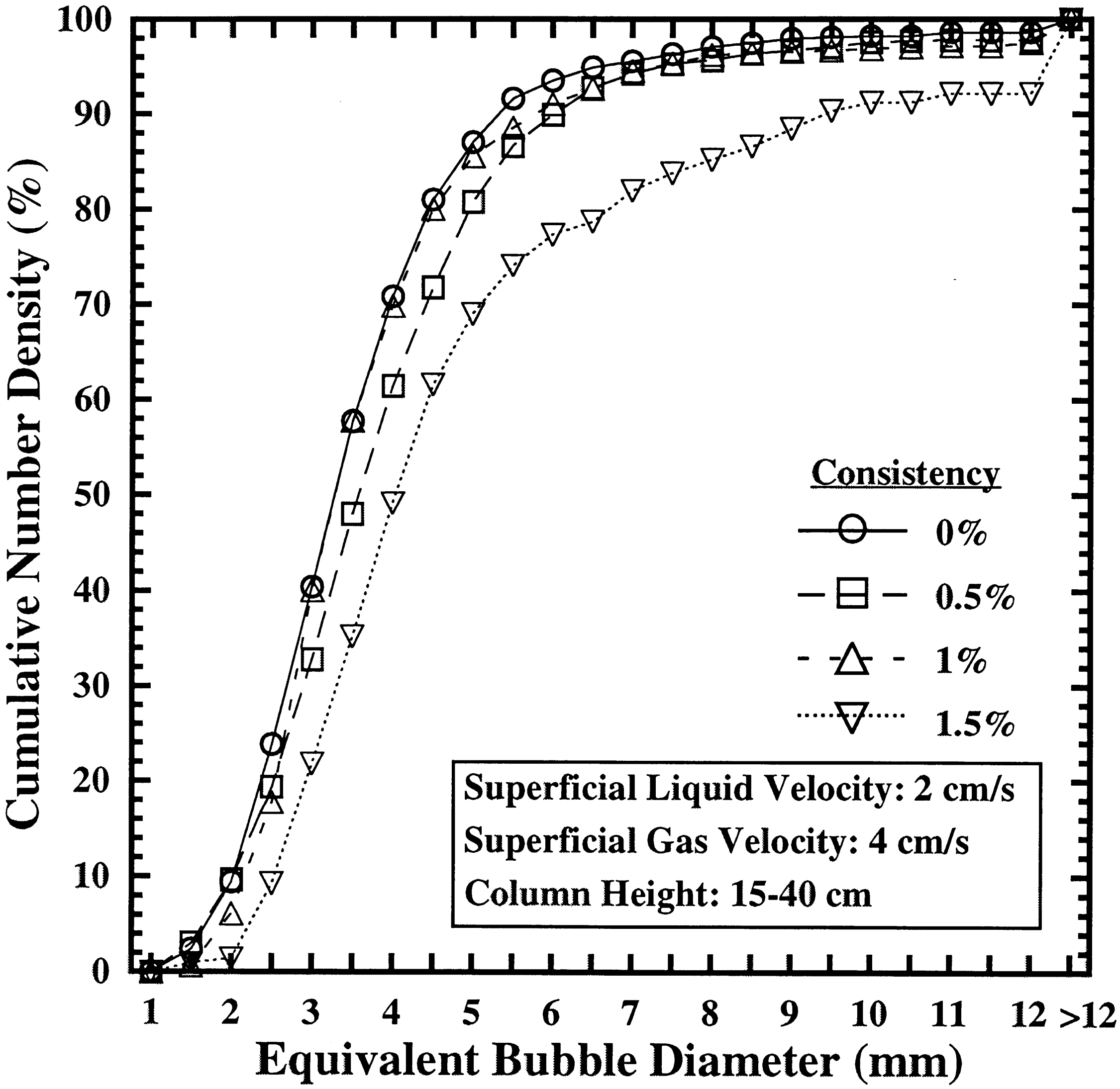

Figure 29: Effect of copy paper consistency on the bubble size cumulative number density for υ_g = 4 cm/s and H = 15-40 cm.

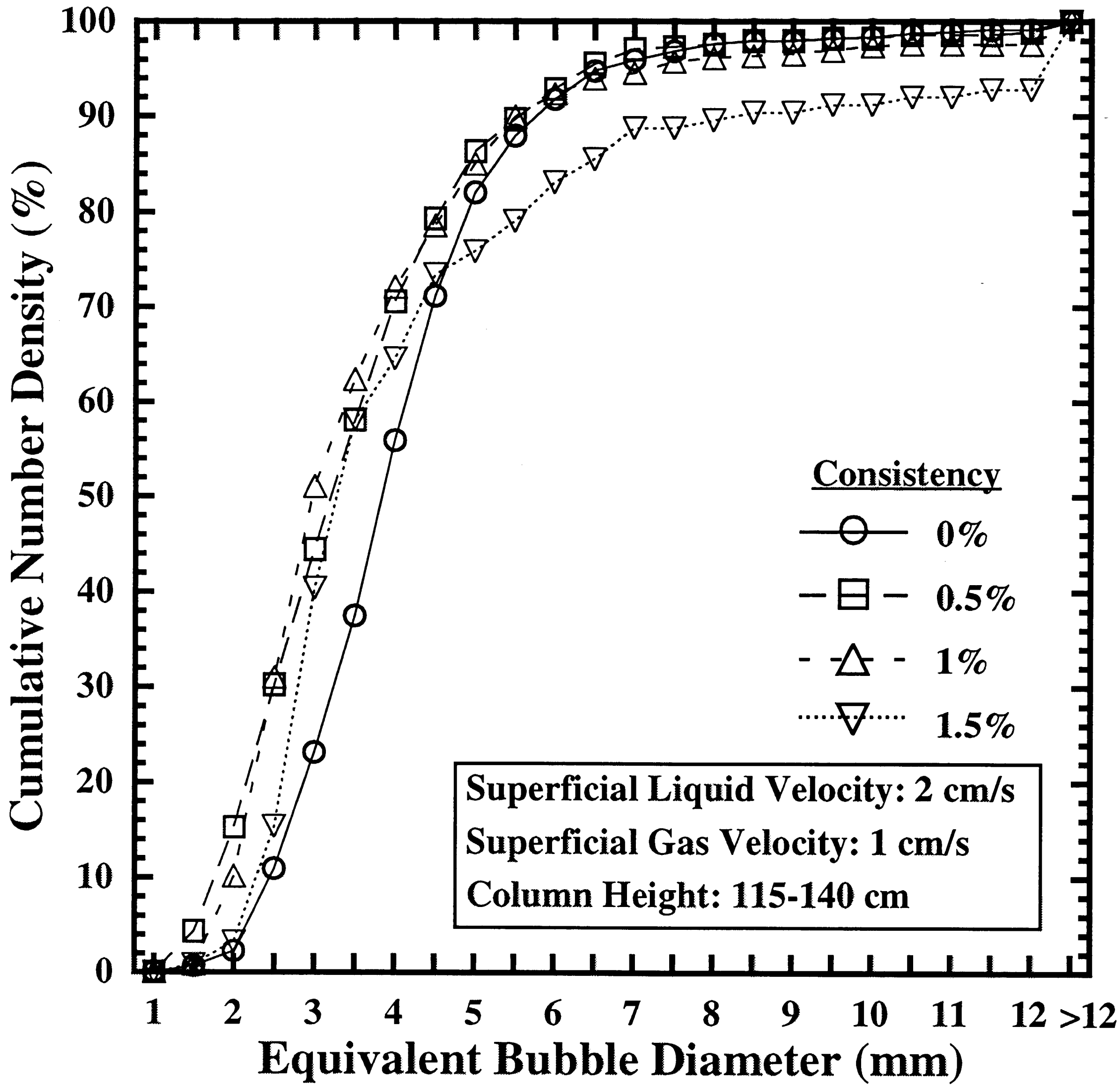

Figure 30: Effect of copy paper consistency on the bubble size cumulative number density for υ_g = 1 cm/s and H = 115-140 cm.

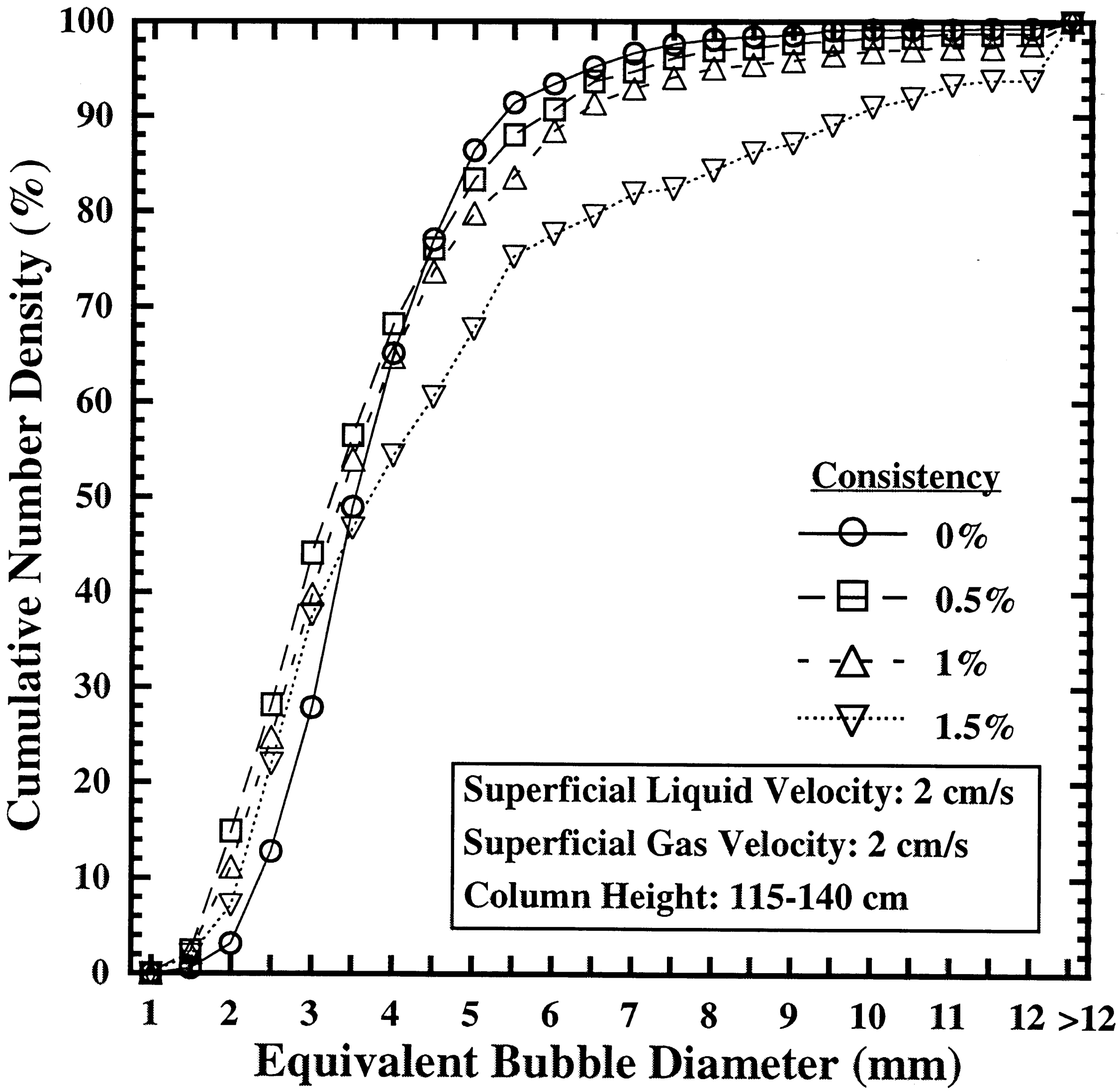

Figure 31: Effect of copy paper consistency on the bubble size cumulative number density for υ_g = 2 cm/s and H = 115-140 cm.

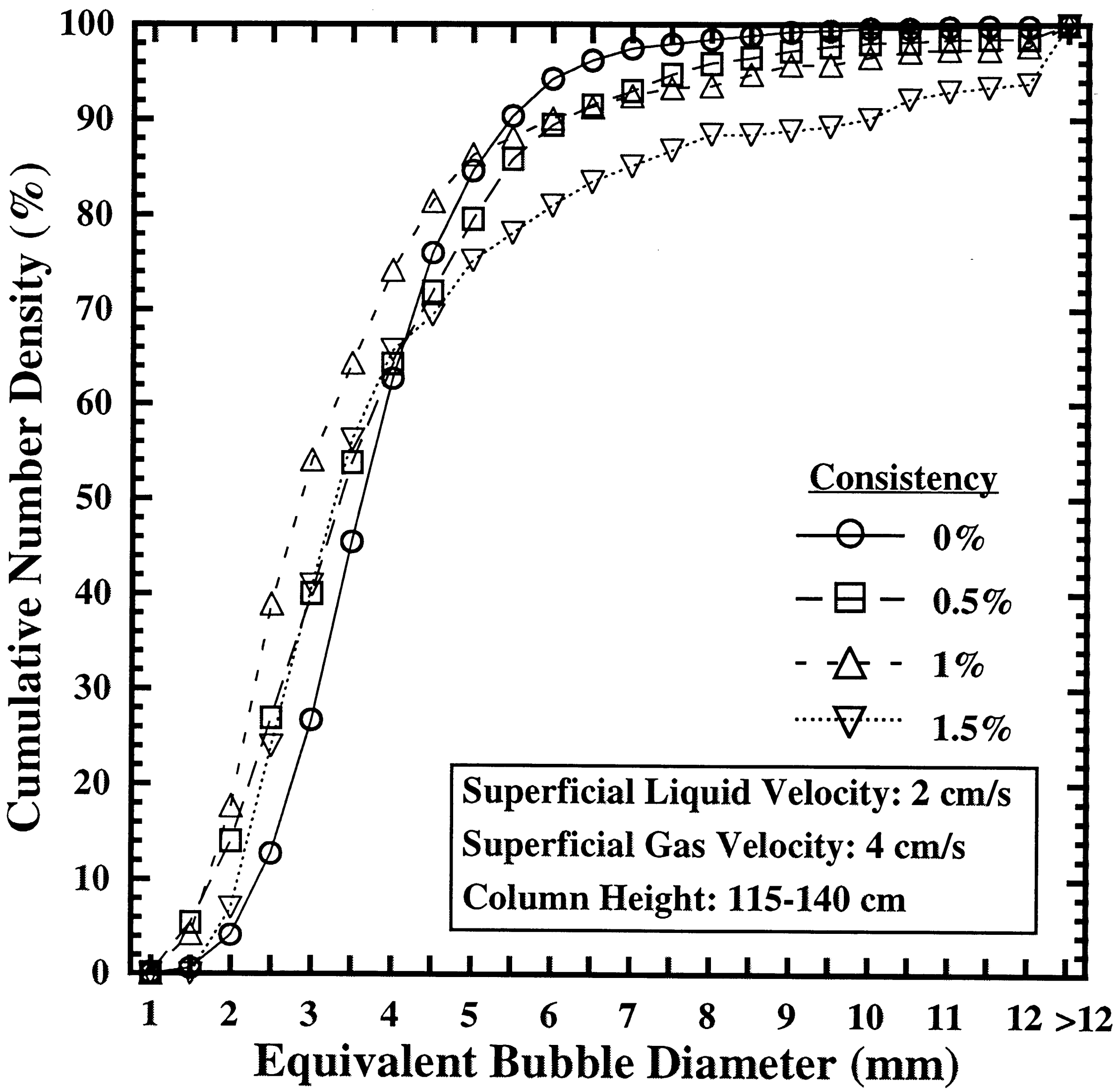

Figure 32: Effect of copy paper consistency on the bubble size cumulative number density for υ_g = 4 cm/s and H = 115-140 cm.

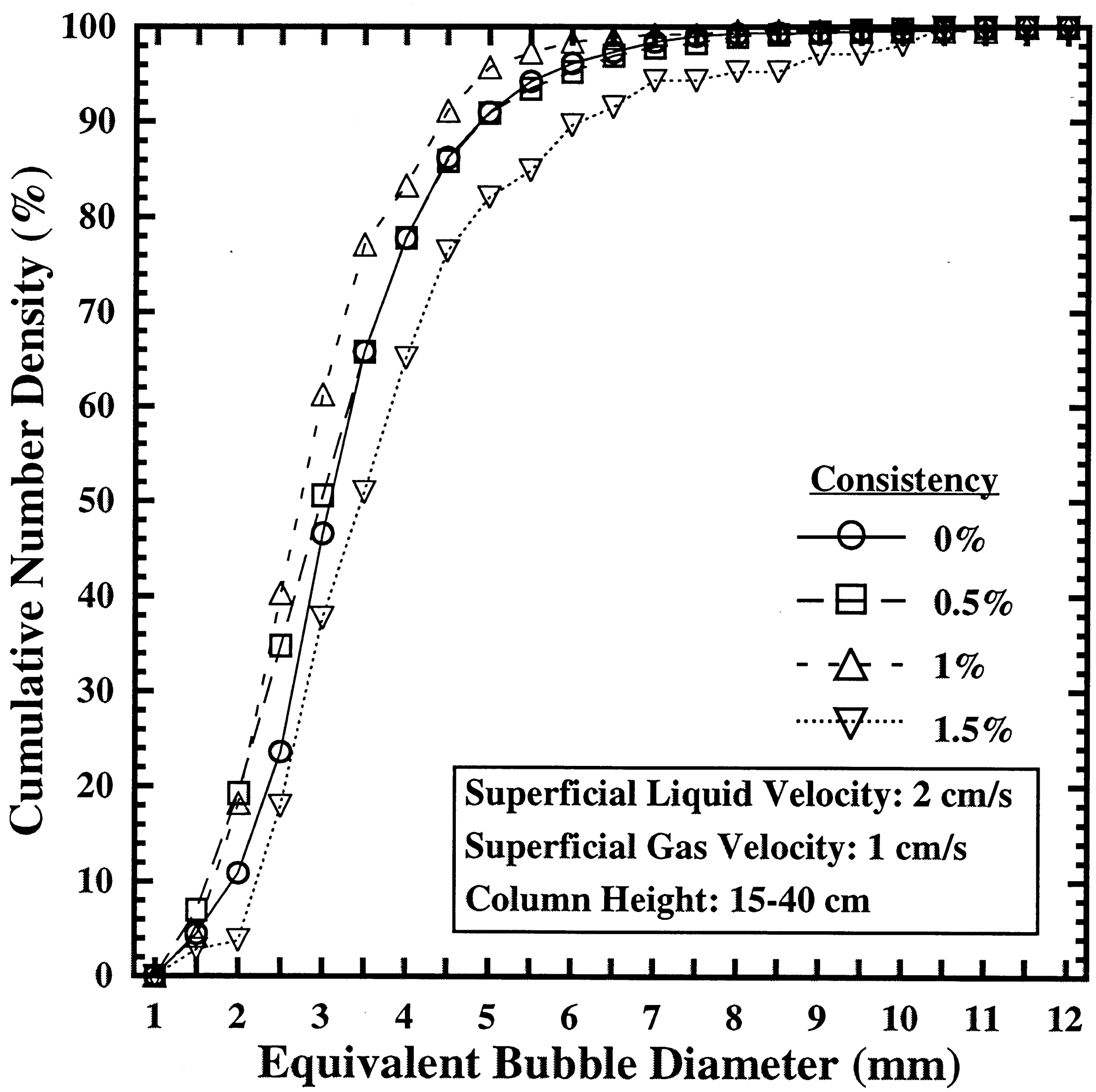

Figure 33: Effect of copy paper consistency on the bubble size cumulative number density for all bubbles with $d \leq 12$ mm and $\upsilon_g = 1$ cm/s and H = 15-40 cm.

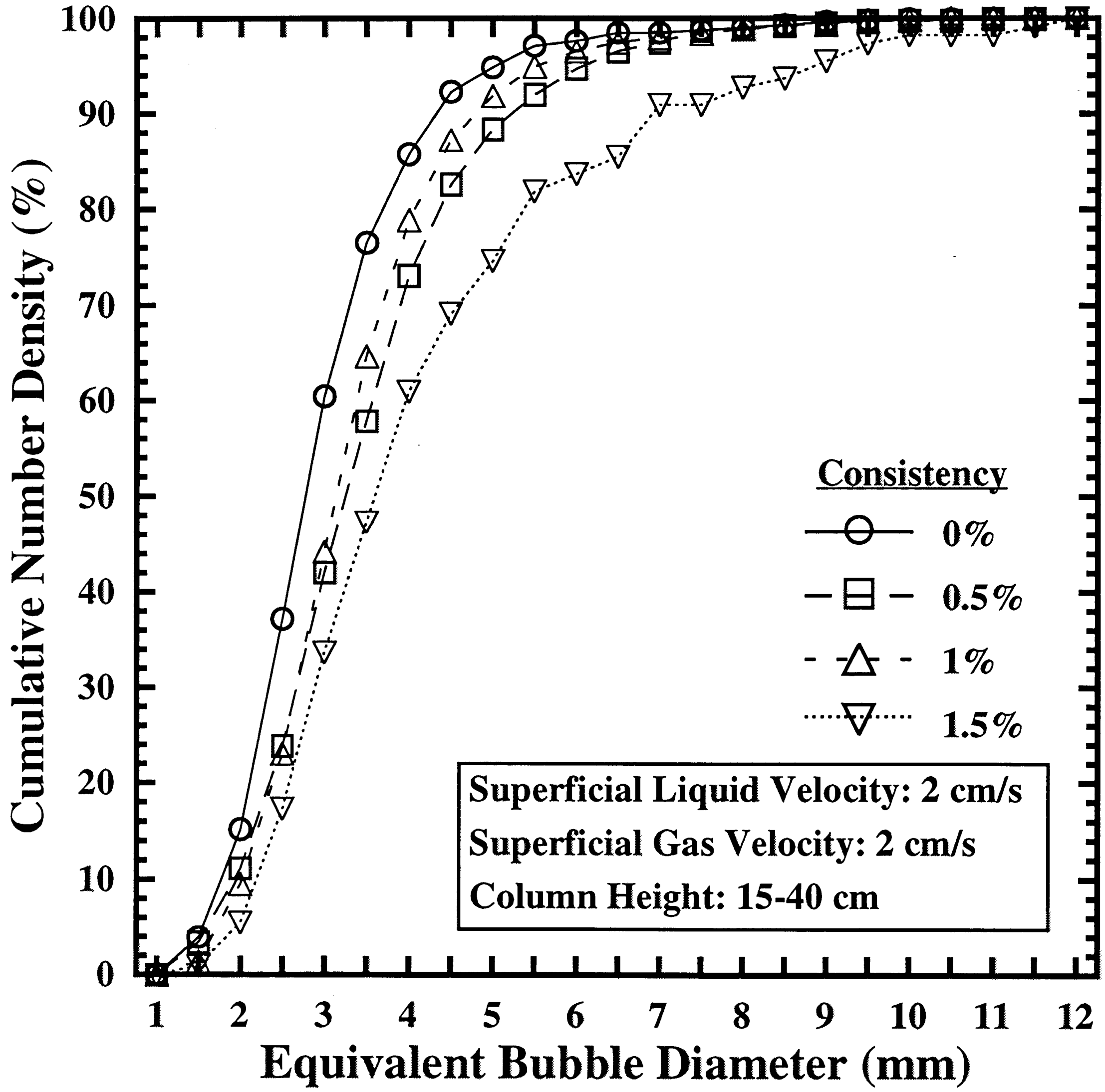

Figure 34: Effect of copy paper consistency on the bubble size cumulative number density for all bubbles with d ≤ 12 mm and υ_g = 2 cm/s and H = 15-40 cm.

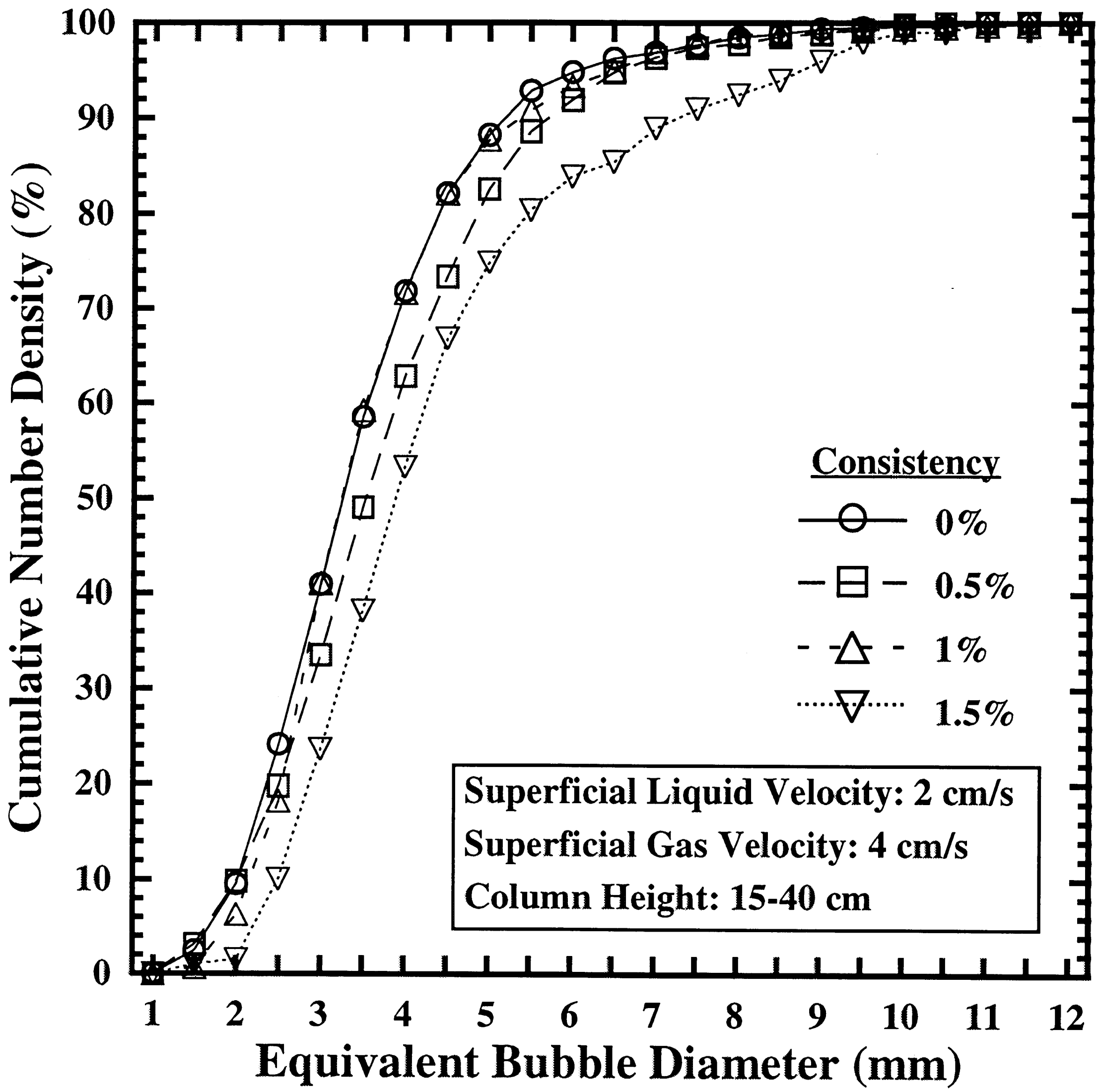

Figure 35: Effect of copy paper consistency on the bubble size cumulative number density for all bubbles with $d \leq 12$ mm and $\upsilon_g = 4$ cm/s and H = 15-40 cm.

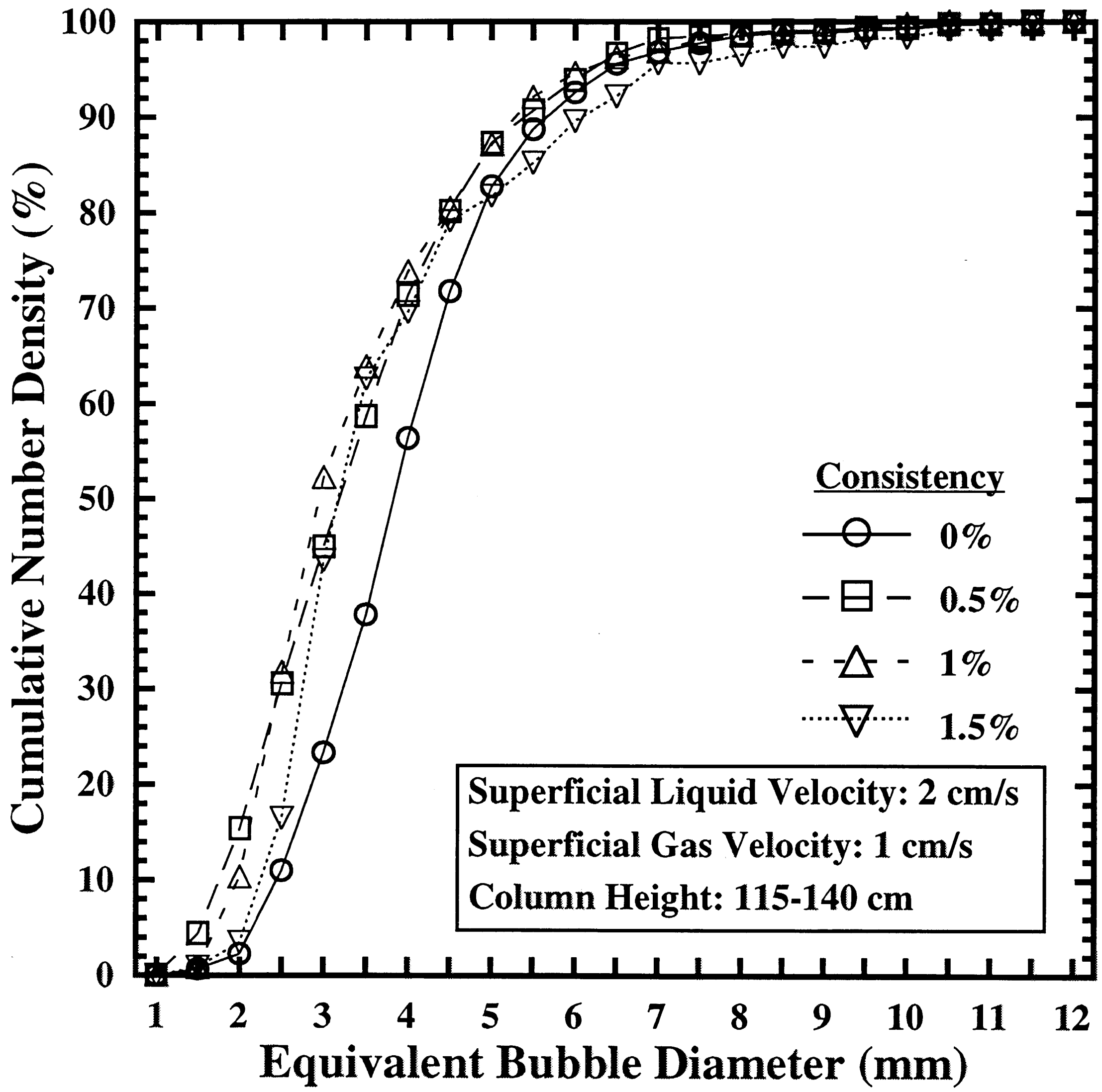

Figure 36: Effect of copy paper consistency on the bubble size cumulative number density for all bubbles with d ≤ 12 mm and υ_g = 1 cm/s and H = 115-140 cm.

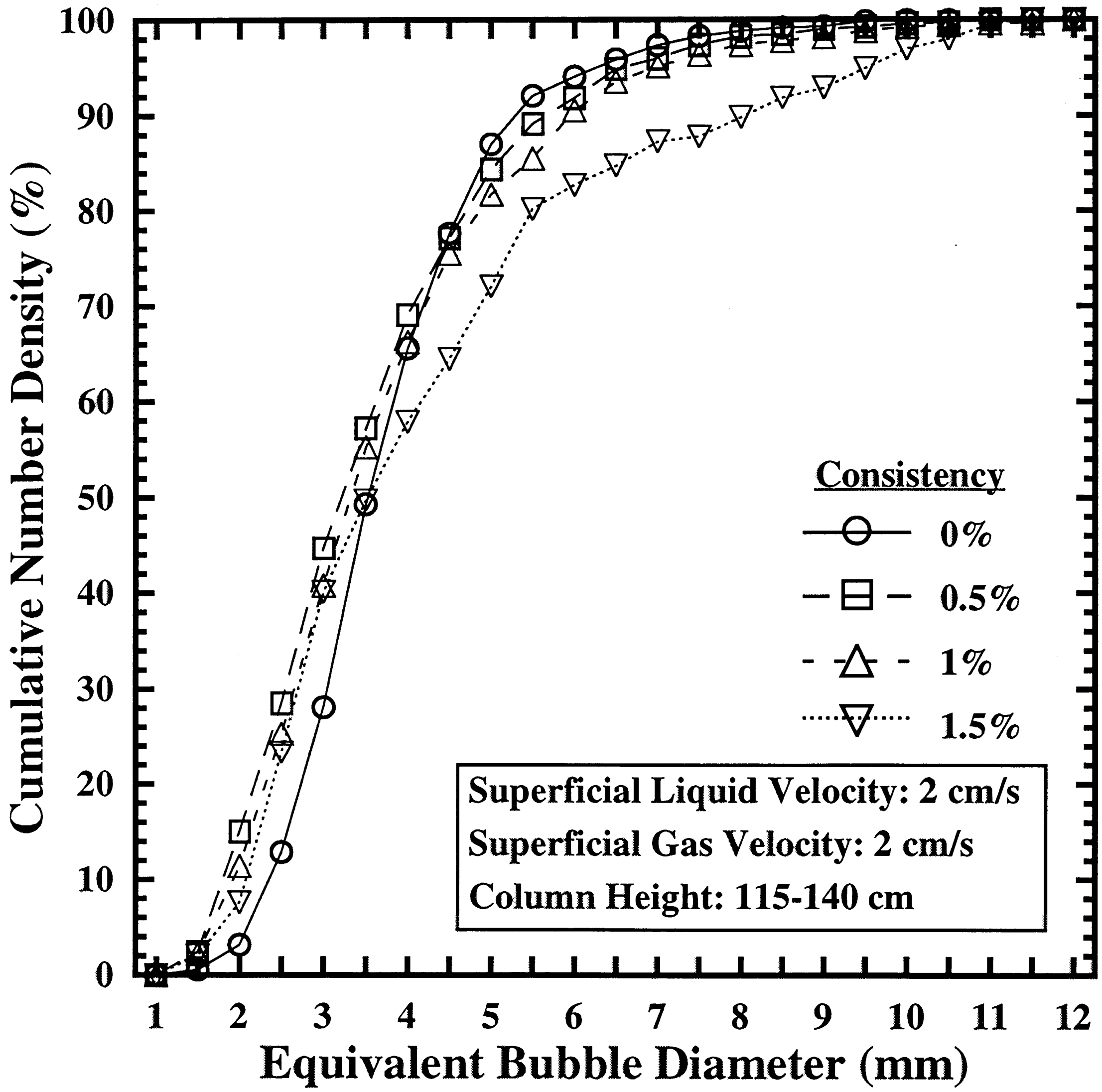

Figure 37: Effect of copy paper consistency on the bubble size cumulative number density for all bubbles with d ≤ 12 mm and υ_g = 2 cm/s and H = 115-140 cm.

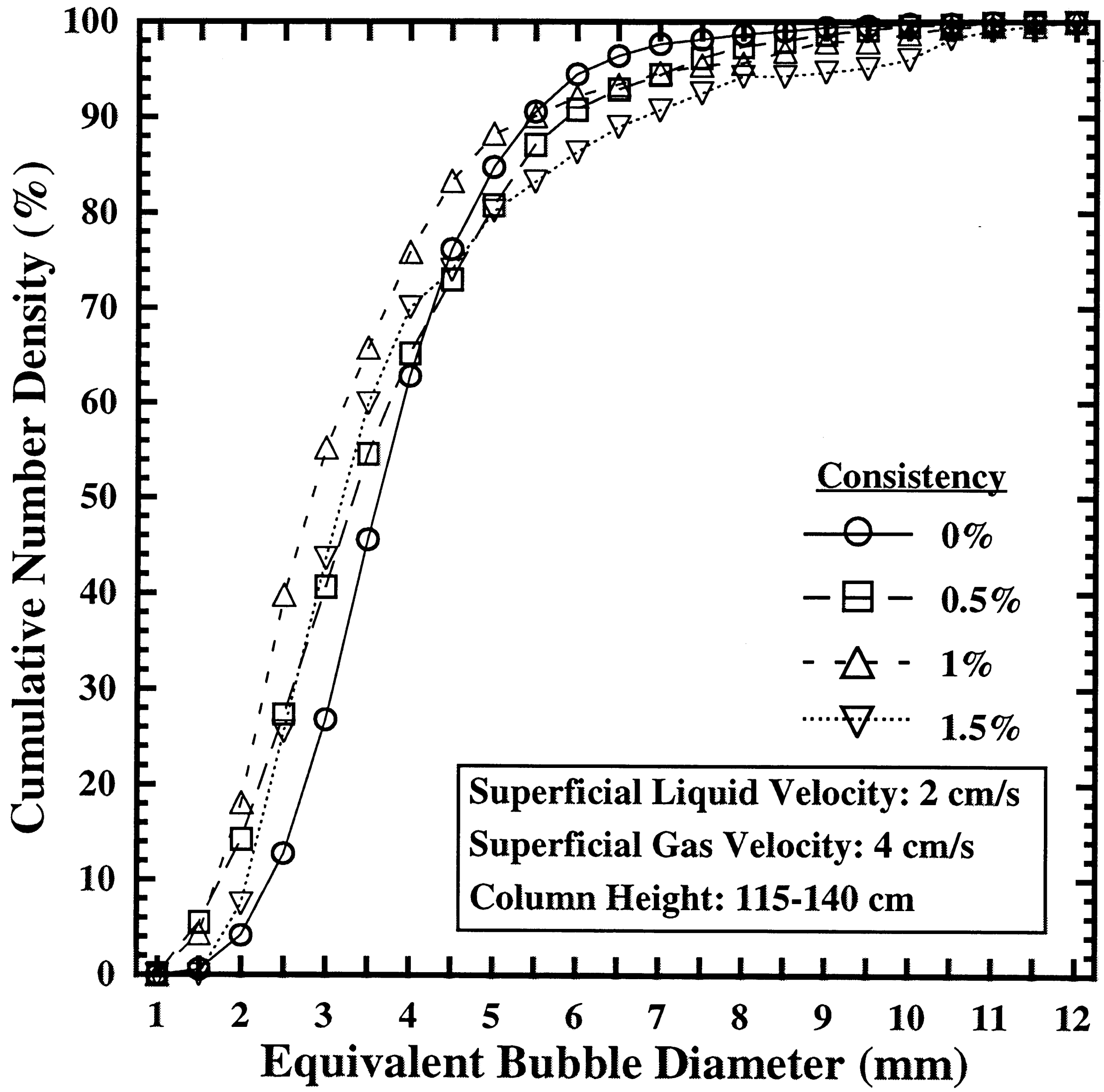

Figure 38: Effect of copy paper consistency on the bubble size cumulative number density for all bubbles with $d \leq 12$ mm and $\upsilon_g = 4$ cm/s and H = 115-140 cm.

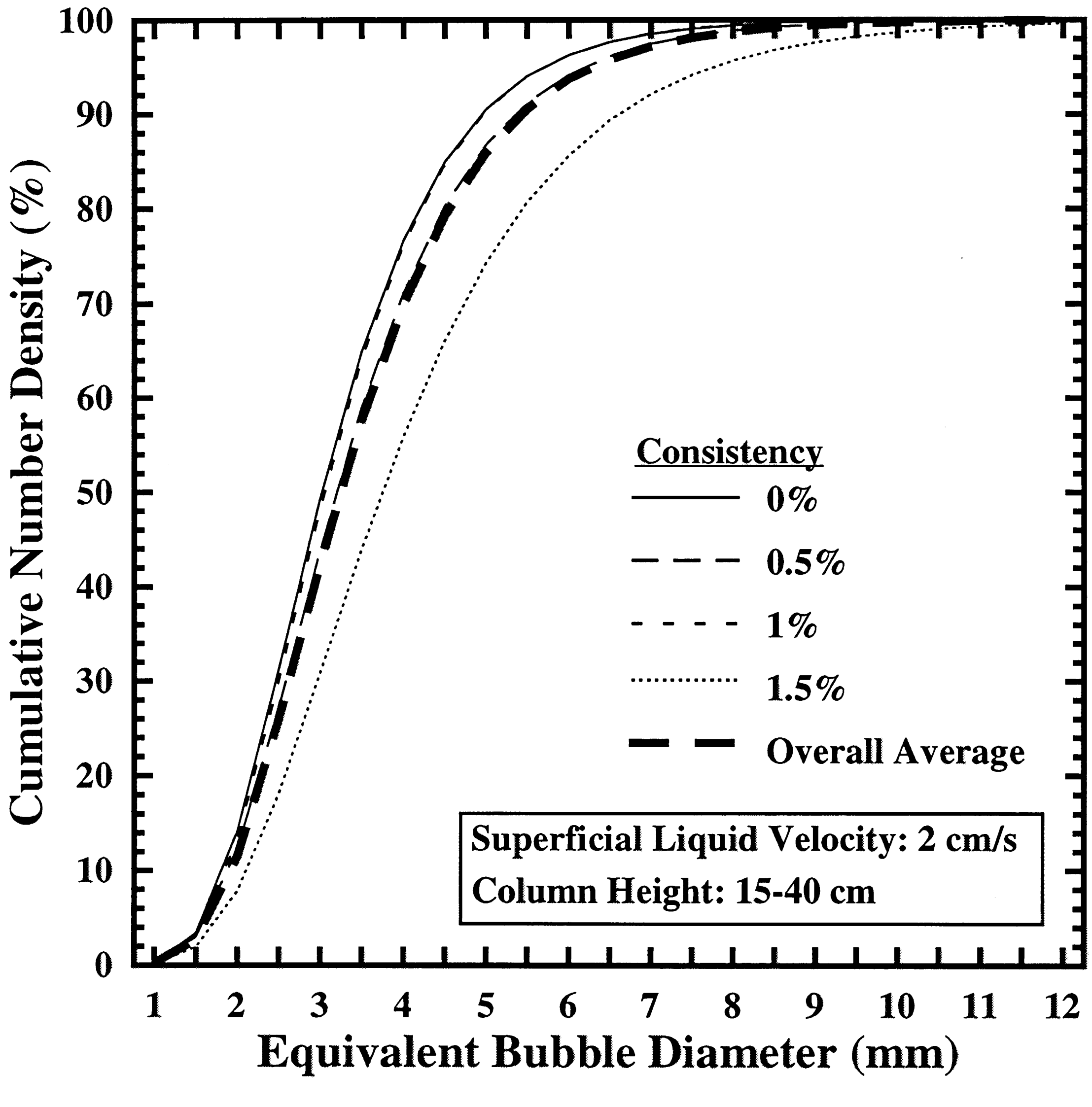

Figure 39: The average lognormal distributions in the lower column region (H = 15-40 cm) for all copy paper consistencies.

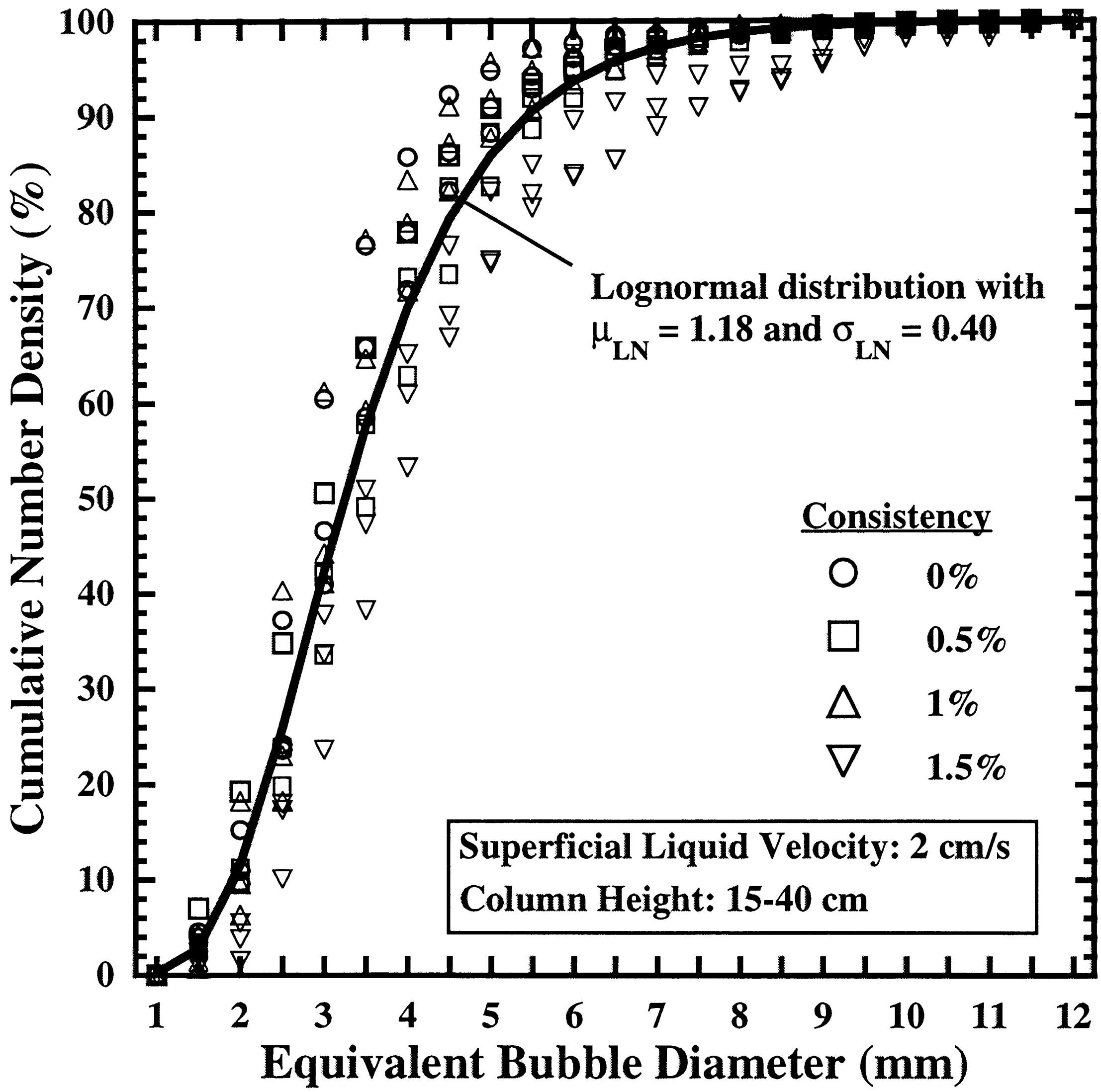

Figure 40: All lower column (H = 15-40 cm) experimental data compared to the overall average lognormal distribution for the lower column region.

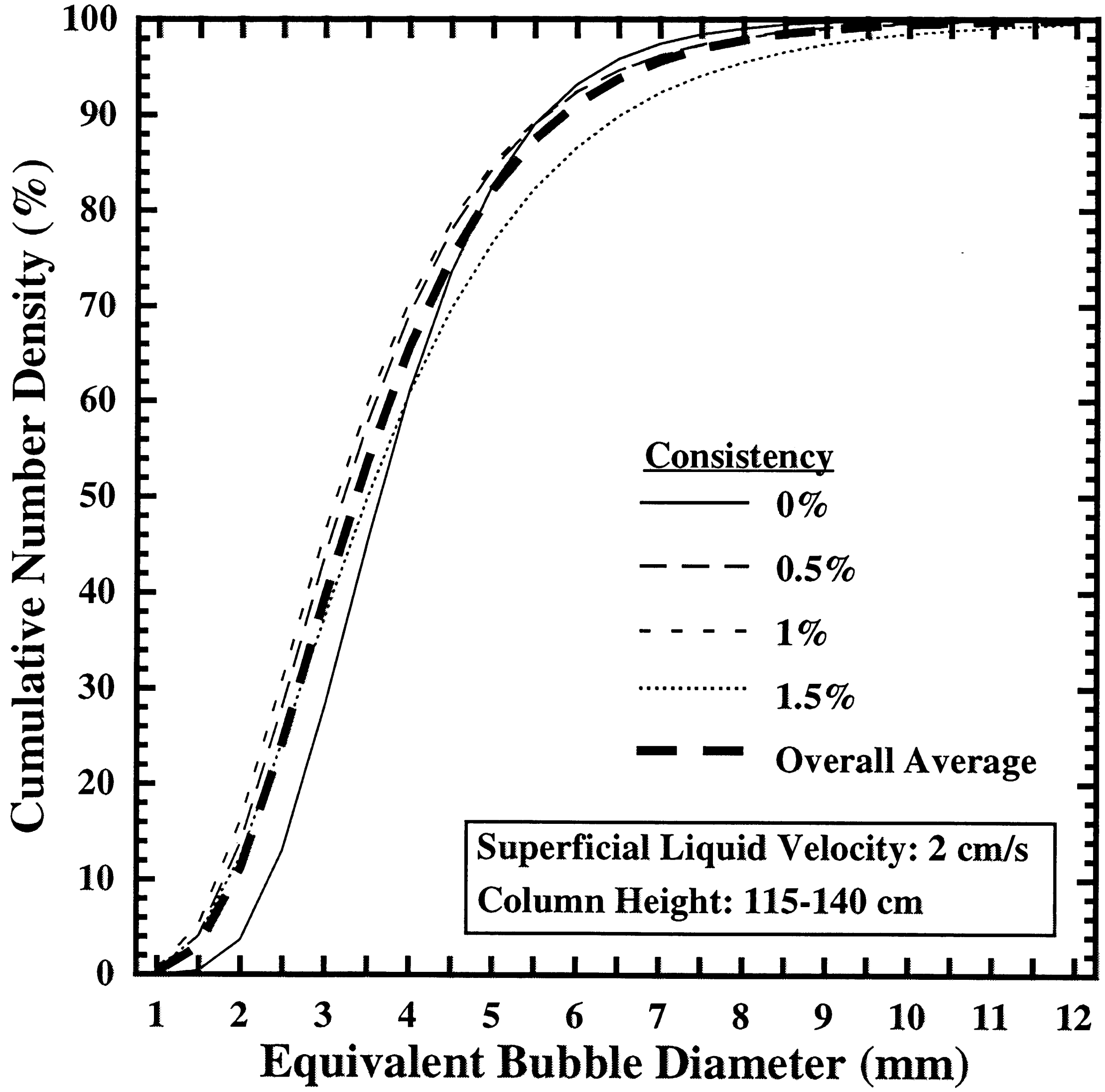

Figure 41: The average lognormal distributions in the upper column region (H = 115-140 cm) for all copy paper consistencies.

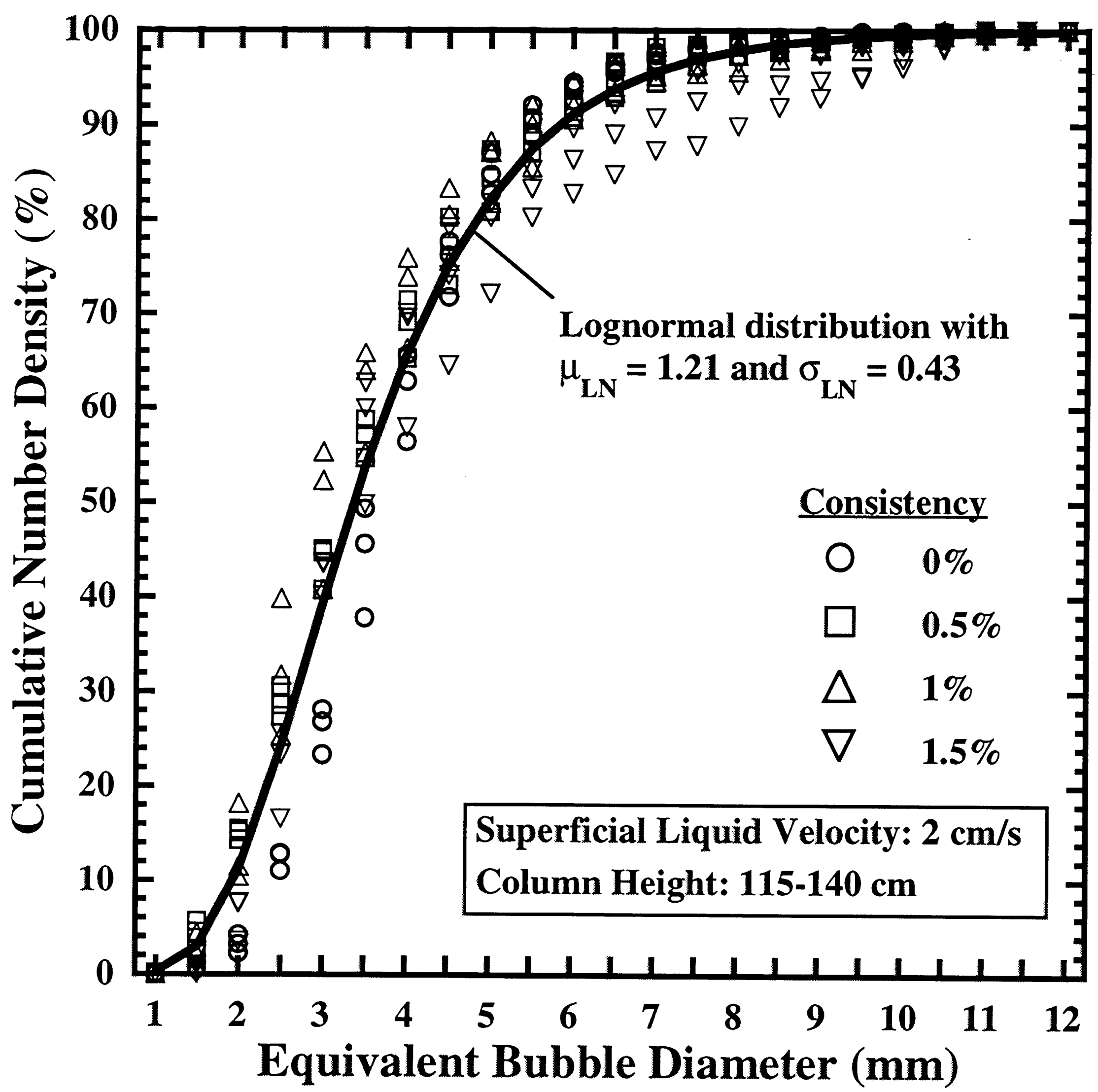

Figure 42: All upper column (H = 115-140 cm) experimental data compared to the overall average lognormal distribution for the upper column region.

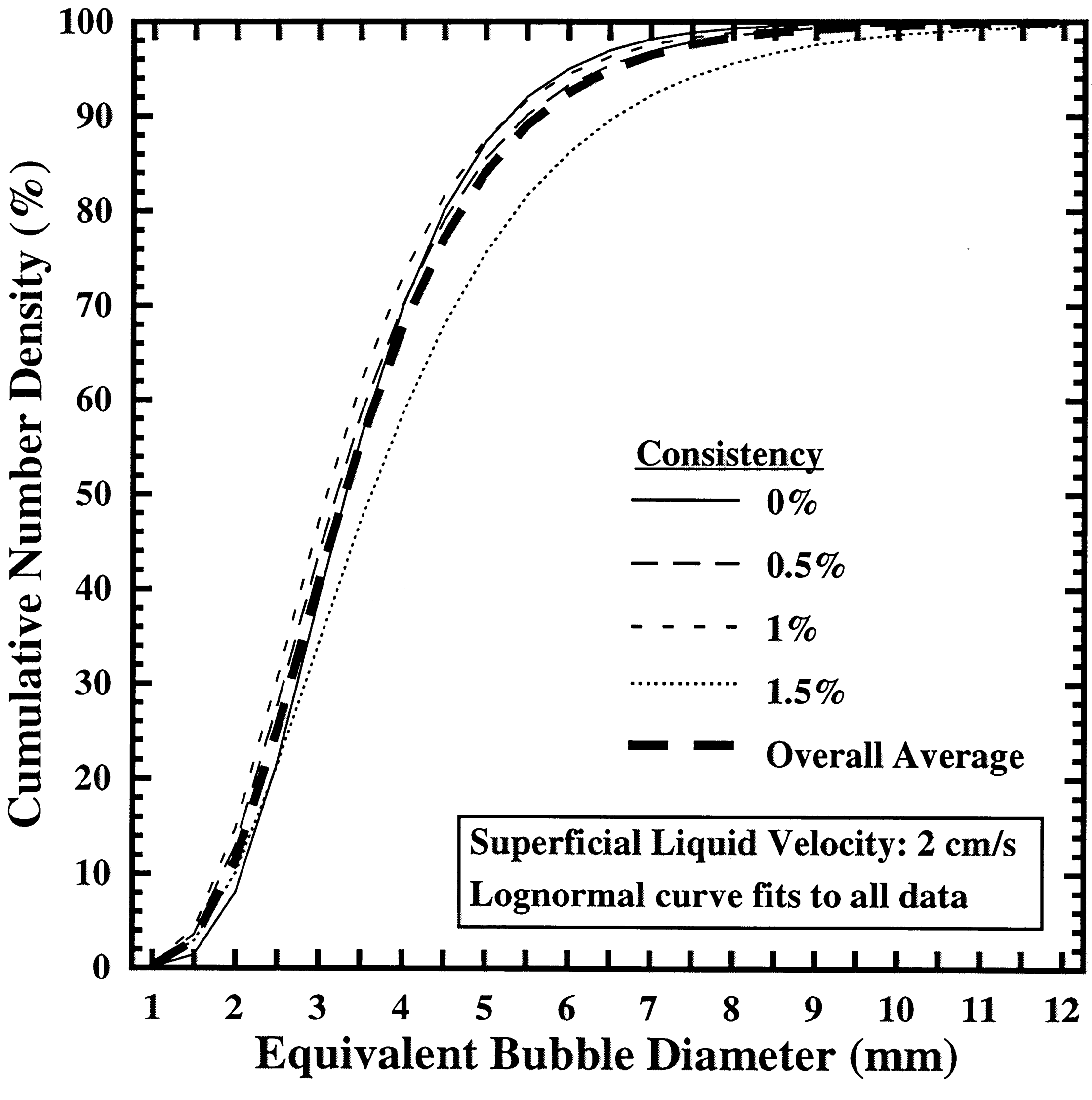

Figure 43: Overall average lognormal distributions for the combined lower and upper column regions and all copy paper consistencies.

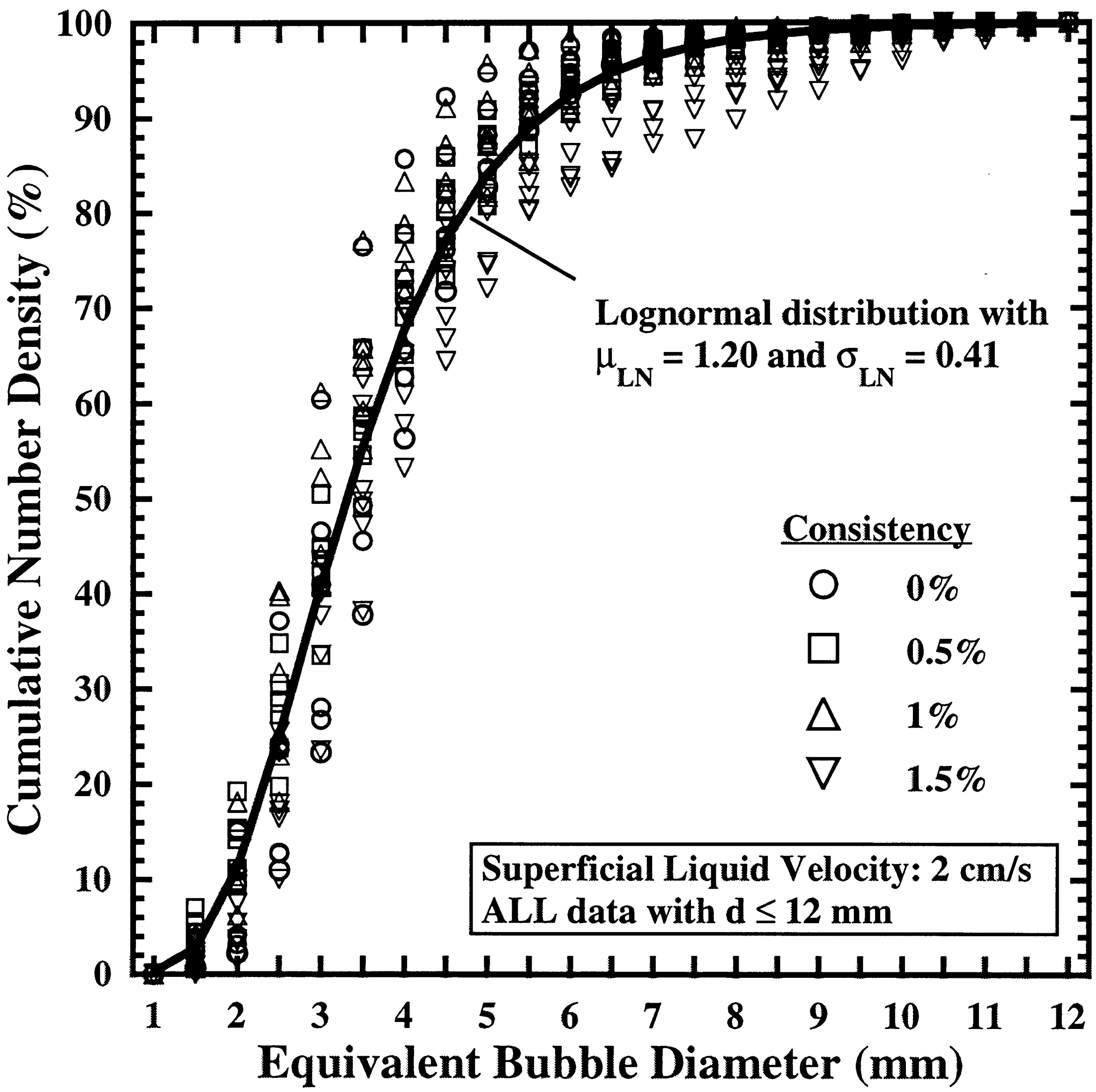

Figure 44: All experimental data compared to the combined overall average lognormal distribution for the lower and upper column regions.

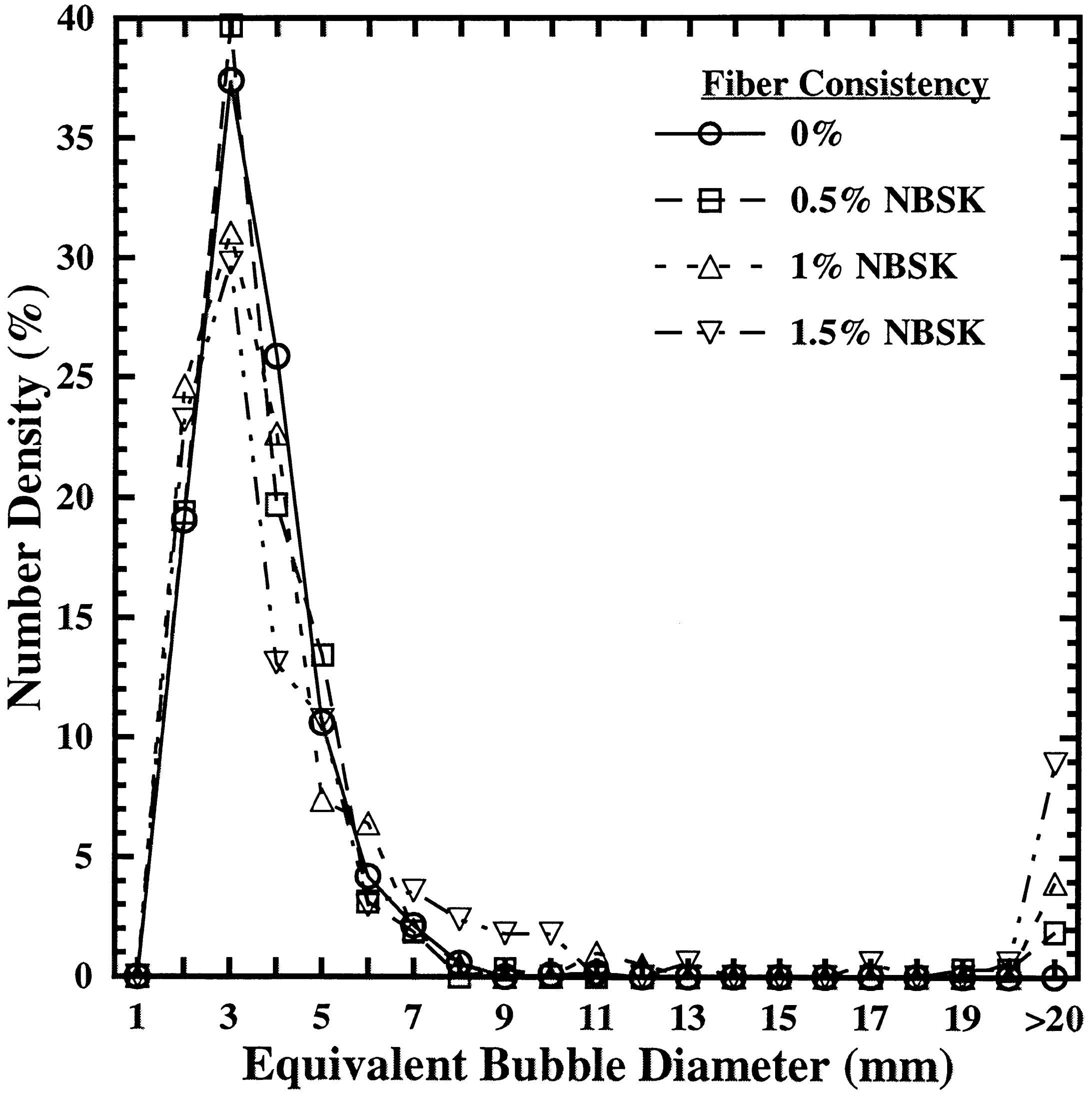

Figure 45: Bubble size number densities obtained using NBSK in a quiescent bubble column with sparger air injection [2].

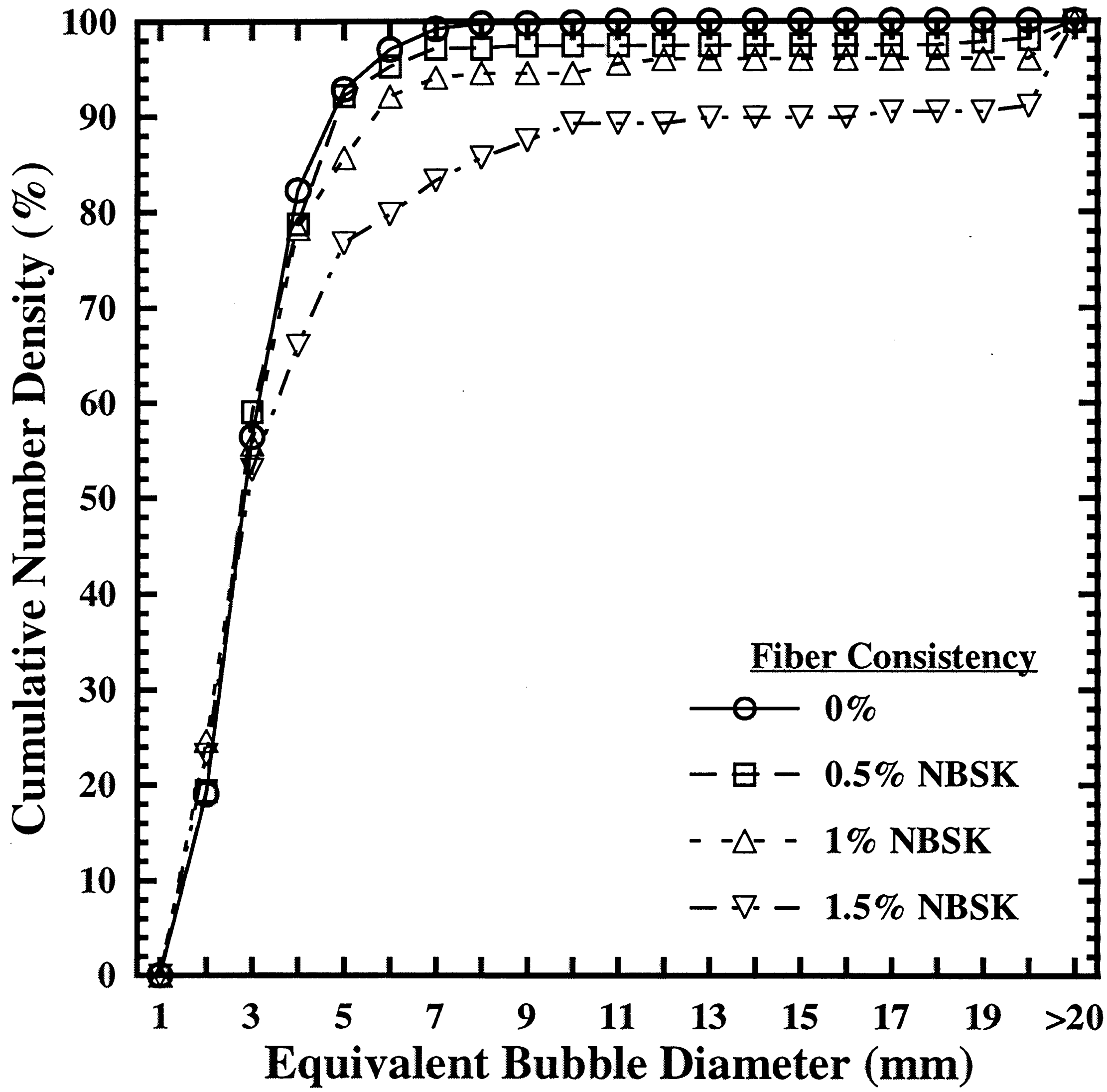

Figure 46: Bubble size cumulative number densities using NBSK in a quiescent bubble column with sparger air injection.

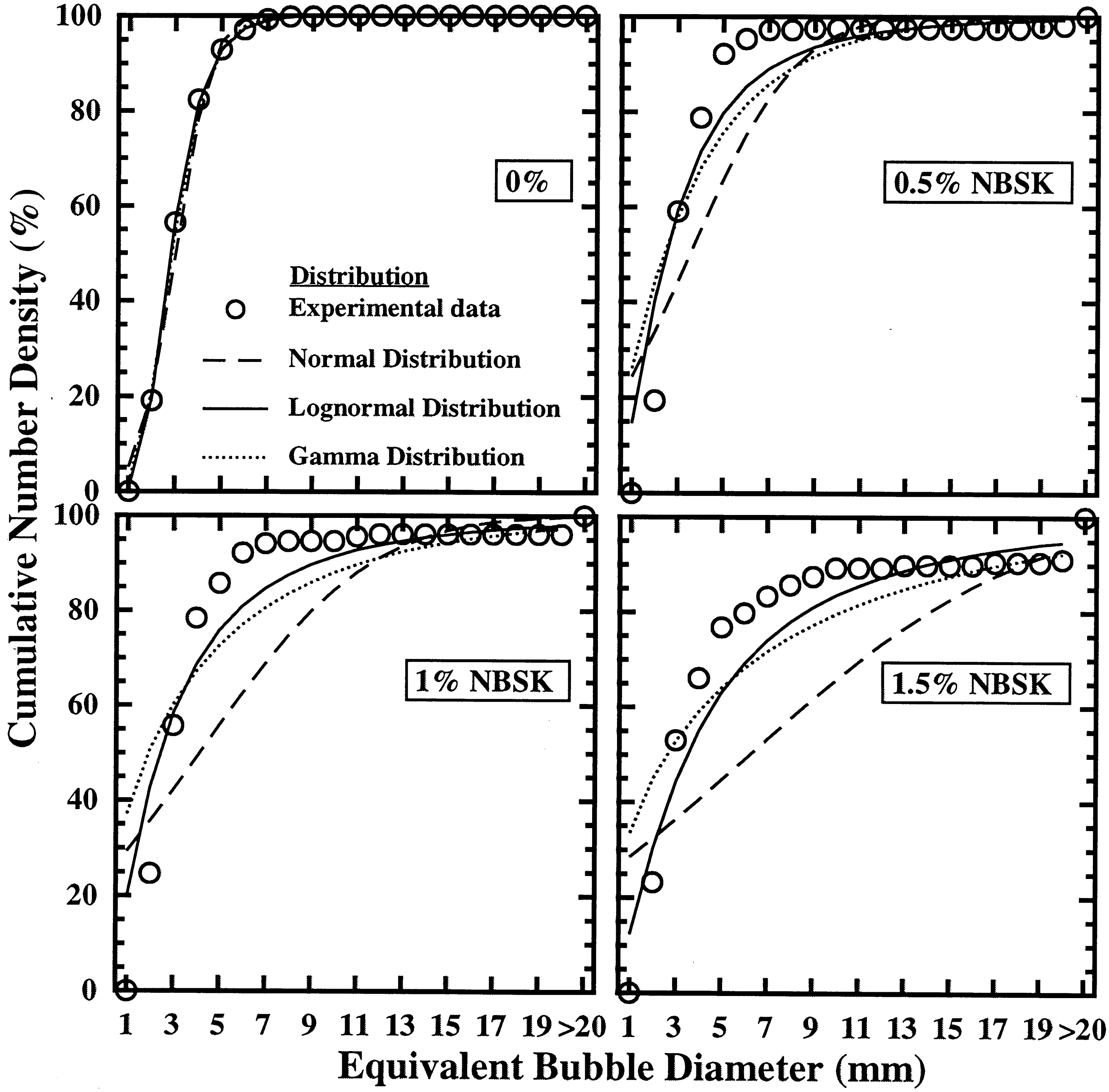

Figure 47: Normal, lognormal, and gamma distribution curve fits to all NBSK data obtained in a quiescent bubble column with sparger air injection.

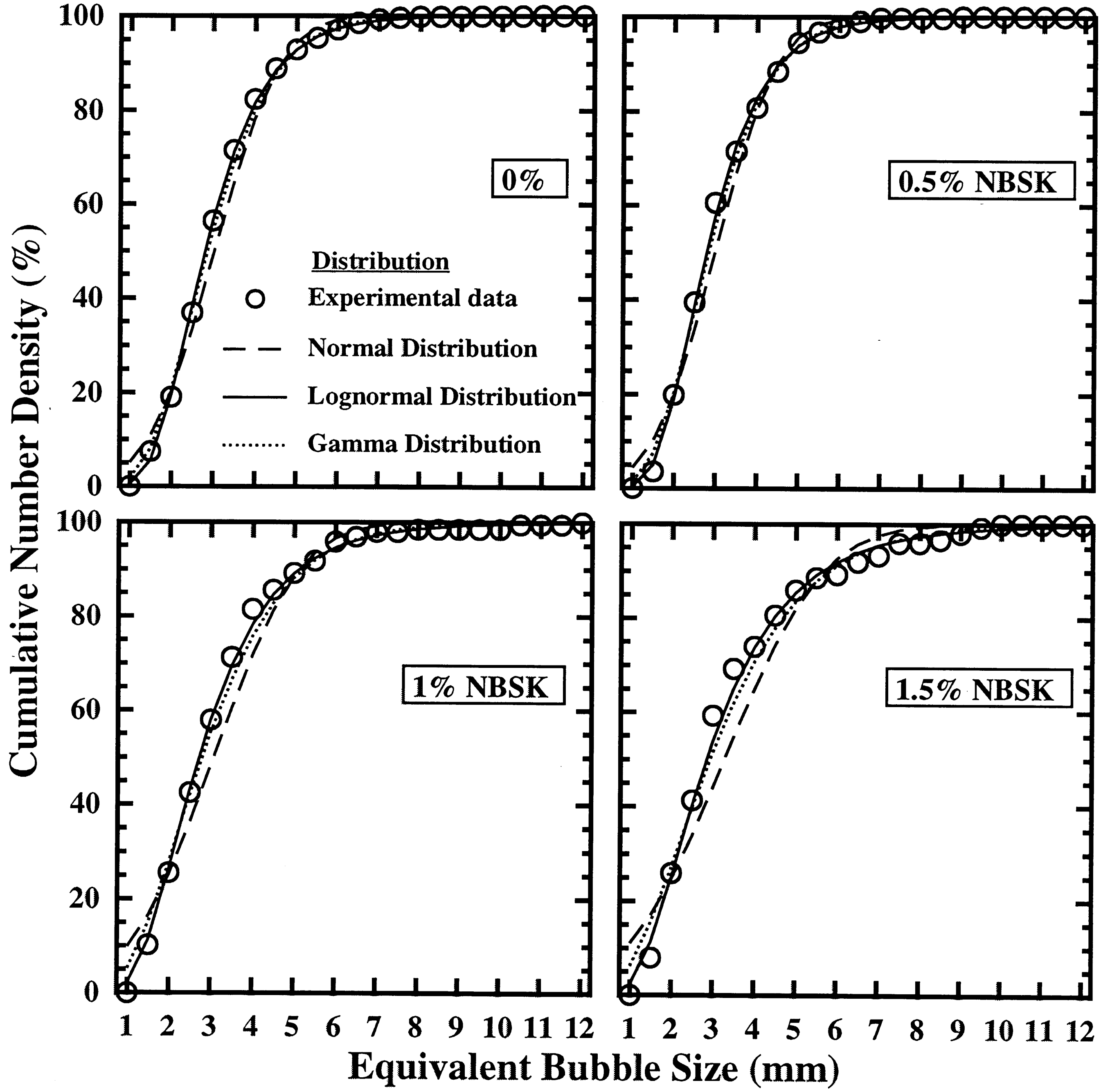

Figure 48: Normal, lognormal, and gamma distribution curve fits to all NBSK data with d ≤ 12 mm and obtained in a quiescent bubble column with sparger air injection.

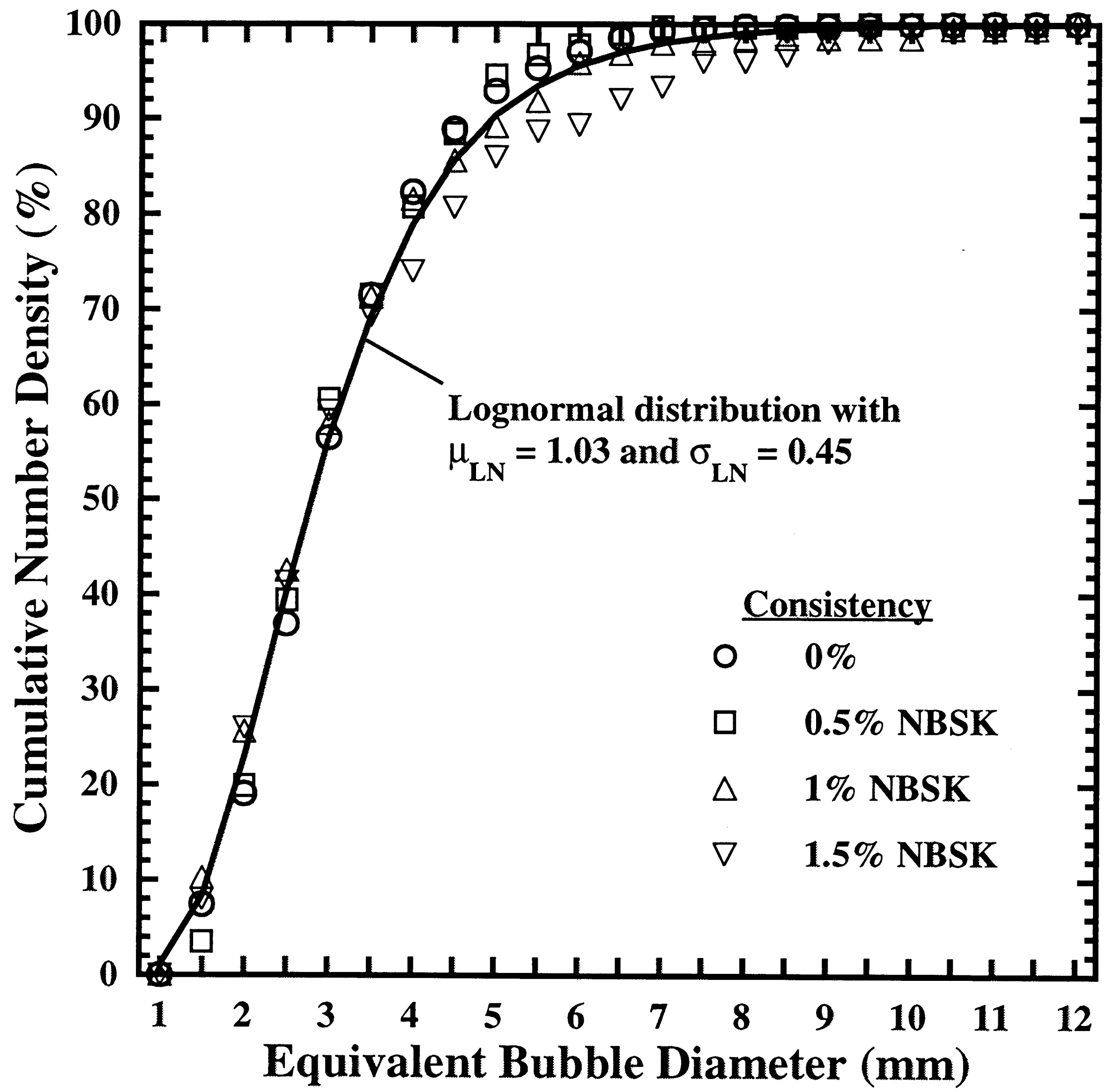

Figure 49: The average lognormal distribution for all NBSK data with d ≤ 12 mm and obtained in a quiescent bubble column with sparger air injection.

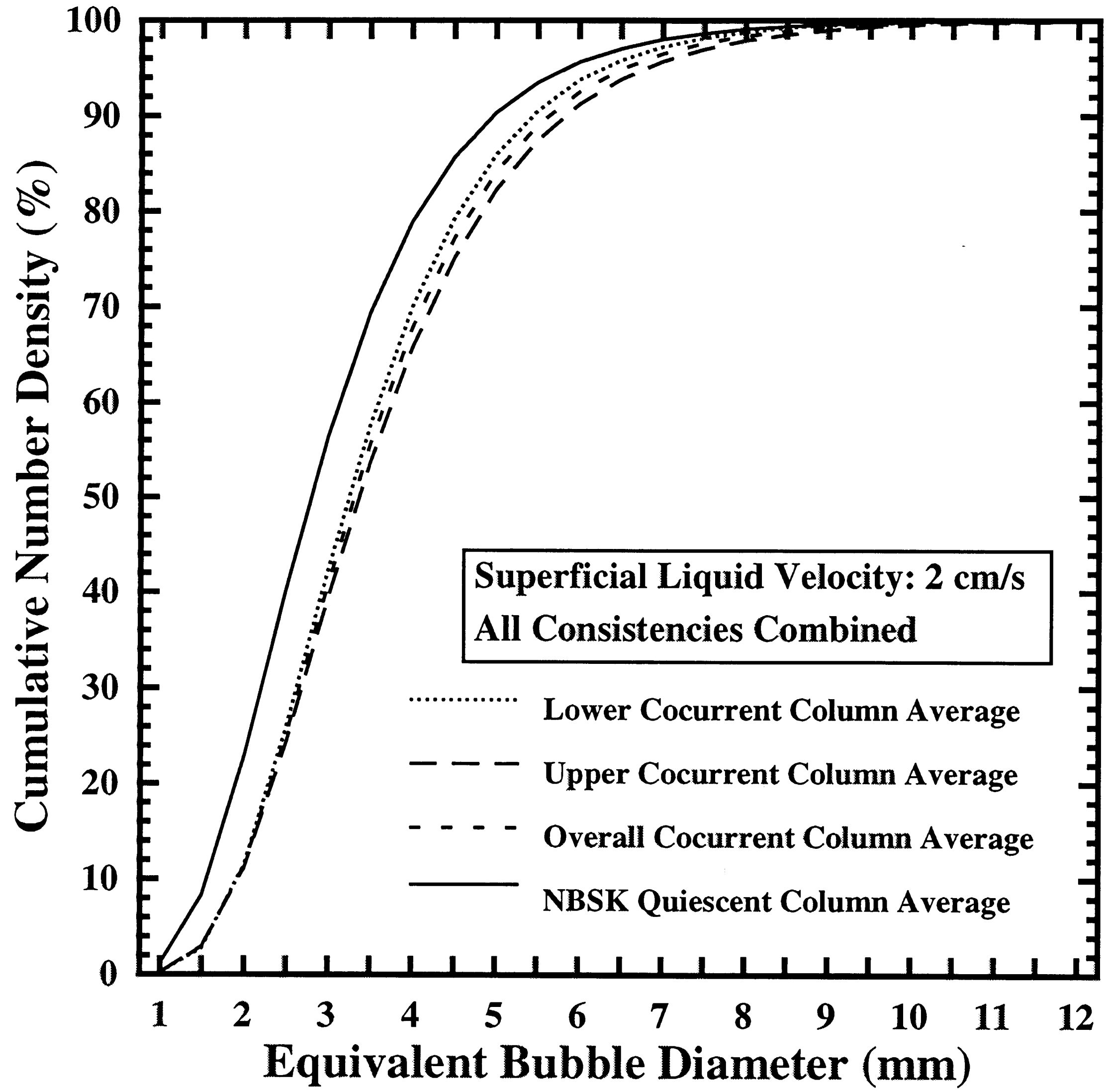

Figure 50: Comparison between the average lognormal distribution for all NBSK data with d ≤ 12 mm and the average lognormal distributions for the cocurrent bubble column.

Appendix A1 - Equivalent Bubble Size Measurements for the Air/Water System

This appendix tabulates the equivalent bubble diameter measurements recorded for the air/water system flowing through the cocurrent bubble column. Table A1.1 summarizes the equivalent bubble diameter number density for all bubble diameters. Table A1.2 tabulates the equivalent bubble diameter number density for all data with $d \leq 12$ mm. Table A1.3 presents all of the equivalent bubble diameter measurements obtained from the FXR images.

Table Al. 1: Summary of the equivalent bubble diameter number density for all the air/water data obtained in this study.

Copy Paper Consistency (%)	0	0	0	0	0	0
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
$0 < d \leq 1$	0.0	0.0	0.0	0.0	0.0	0.0
$1 < d \leq 1.5$	4.4	3.9	2.4	0.7	0.5	0.6
$1.5 < d \leq 2$	6.3	11.1	7.0	1.6	2.6	3.6
$2 < d \leq 2.5$	12.6	21.8	14.4	8.7	9.6	8.6
$2.5 < d \leq 3$	22.7	23.0	16.6	12.2	15.1	14.0
$3 < d \leq 3.5$	19.0	15.9	17.3	14.3	21.1	18.7
$3.5 < d \leq 4$	11.8	9.1	13.1	18.4	16.1	17.2
$4 < d \leq 4.5$	8.3	6.5	10.2	15.2	11.9	13.3
$4.5 < d \leq 5$	4.6	2.5	6.0	10.9	9.3	8.6
$5 < d \leq 5.5$	3.3	2.3	4.6	5.9	5.0	5.8
$5.5 < d \leq 6$	1.9	0.5	1.9	3.8	2.0	3.9
$6 < d \leq 6.5$	1.2	0.9	1.4	3.0	1.8	1.9
$6.5 < d \leq 7$	1.1	0.0	0.6	1.2	1.5	1.3
$7 < d \leq 7.5$	0.6	0.3	0.8	0.9	0.9	0.4
$7.5 < d \leq 8$	0.2	0.3	0.8	0.8	0.5	0.5
$8 < d \leq 8.5$	0.1	0.3	0,4	0.3	0.3	0.4
$8.5 < d \leq 9$	0.0	0.4	0.5	0.0	0.1	0.4
$9 < d \leq 9.5$	0,2	0.1	0.1	0.3	0.5	0.1
$9.5 < d \leq 10$	[illegible]	01 .	0.1	0.1	0.1	0.2
$10 < d \leq 10.5$	01 .	0.0	0.0	0.4	0.0	0.0
$10.5 < d \leq 11$	02 .	0.0	0,4	0.1	0.0	0.1
$11 < d \leq 11.5$	01 .	0.0	0.0	0.3	0.1	0.1
$11.5 < d \leq 12$	0.0	0.1	0.0	0.0	0.0	0.0
$d > 12$	1.2	11 .	1,4	0.9	0.7	0.2

Table A1.2: Summary of the equivalent bubble diameter number density for the d ≤ 12 mm air/water data obtained in this study.

Copy Paper Consistency (%)	0	0	0	0	0	0
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
0 < d ≤ 1	0.0	0.0	0.0	0.0	0.0	0.0
1 < d ≤ 1.5	4.5	3.9	2.5	0.7	0.5	0.6
1.5 < d ≤ 2	6.4	11.3	7.1	1.6	2.6	3.6
2 < d ≤ 2.5	12.7	22.0	14.6	8.8	9.7	8.6
2.5 < d ≤ 3	23.0	23.3	16.8	12.3	15.2	14.0
3 < d ≤ 3.5	19.2	16.1	17.6	14.5	21.2	18.8
3.5 < d ≤ 4	12.0	9.2	13.3	18.6	16.3	17.2
4 < d ≤ 4.5	8.4	6.6	10.3	15.4	12.0	13.4
4.5 < d ≤ 5	4.7	2.5	6.1	11.0	9.4	8.6
5 < d ≤ 5.5	3.3	2.3	4.7	6.0	5.1	5.8
5.5 < d ≤ 6	1.9	0.5	1.9	3.8	2.0	3.9
6 < d ≤ 6.5	1.2	0.9	1.4	3.1	1.8	1.9
6.5 < d ≤ 7	1.1	0.0	0.6	1.2	1.5	1.3
7 < d ≤ 7.5	0.6	0.3	0.8	0.9	1.0	0.4
7.5 < d ≤ 8	0.2	0.3	0.8	0.8	0.5	0.5
8 < d ≤ 8.5	0.1	0.3	0.4	0.3	0.3	0.4
8.5 < d ≤ 9	0.0	0.4	0.5	0.0	0.1	0.4
9 < d ≤ 9.5	0.2	0.1	0.1	0.3	0.5	0.1
9.5 < d ≤ 10	0.0	0.1	0.1	0.1	0.1	0.2
10 < d ≤ 10.5	0.1	0.0	0.0	0.4	0.0	0.0
10.5 < d ≤ 11	0.2	0.0	0.4	0.1	0.0	0.1
11 < d ≤ 11.5	0.1	0.0	0.0	0.3	0.1	0.1
11.5 < d ≤ 12	0.0	0.1	0.0	0.0	0.0	0.0

Table A1.3: Equivalent bubble diameter data for the air/water system flowing through the cocurrent bubble column. The data are sorted by bubble size.

Copy Paper Consistency (%)	0	0	0	0	0	0
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Count	Equivalent Bubble Diameter (mm)					
1	1.01	1.02	1.00	1.20	1.31	1.06
2	1.05	1.04	1.03	1.31	1.38	1.06
3	1.05	1.06	1.06	1.39	1.39	1.10
4	1.06	1.06	1.08	1.47	1.39	1.10
5	1.06	1.06	1.12	1.49	1.45	1.17
6	1.08	1.07	1.13	1.70	1.53	1.41
7	1.08	1.09	1.14	1.71	1.57	1.48
8	1.11	1.09	1.20	1.73	1.58	1.48
9	1.11	1.09	1.21	1.74	1.61	1.52
10	1.13	1.09	1.23	1.74	1.63	1.53
11	1.15	1.14	1.24	1.76	1.65	1.54
12	1.16	1.16	1.27	1.77	1.66	1.57
13	1.18	1.17	1.27	1.81	1.70	1.57
14	1.20	1.22	1.31	1.81	1.71	1.59
15	1.20	1.26	1.33	1.85	1.77	1.60
16	1.20	1.26	1.38	1.86	1.79	1.62
17	1.21	1.27	1.46	1.92	1.82	1.66
18	1.24	1.28	1.47	2.04	1.85	1.66
19	1.24	1.32	1.47	2.06	1.87	1.67
20	1.25	1.32	1.50	2.06	1.88	1.69
21	1.28	1.34	1.50	2.06	1.89	1.71
22	1.29	1.35	1.52	2.08	1.89	1.72
23	1.30	1.38	1.52	2.08	1.95	1.73
24	1.31	1.39	1.52	2.08	1.95	1.75
25	1.32	1.40	1.57	2.09	1.95	1.75
26	1.32	1.41	1.58	2.11	1.95	1.78
27	1.32	1.48	1.60	2.13	1.97	1.79
28	1.33	1.49	1.60	2.14	1.97	1.81
29	1.33	1.49	1.61	2.15	1.97	1.82
30	1.34	1.50	1.62	2.17	1.98	1.83
31	1.35	1.50	1.64	2.17	2.02	1.84
32	1.36	1.51	1.65	2.18	2.02	1.84
33	1.36	1.53	1.69	2.19	2.03	1.85
34	1.41	1.53	1.71	2.20	2.03	1.85
35	1.42	1.54	1.74	2.20	2.05	1.86
36	1.42	1.54	1.74	2.21	2.05	1.86
37	1.44	1.54	1.75	2.22	2.06	1.87
38	1.45	1.56	1.76	2.23	2.07	1.89
39	1.47	1.57	1.77	2.24	2.08	1.89
40	1.47	1.60	1.77	2.24	2.09	1.91
41	1.49	1.61	1.77	2.25	2.12	1.92
42	1.49	1.61	1.79	2.27	2.14	1.93
43	1.54	1.63	1.79	2.28	2.15	1.93
44	1.60	1.64	1.79	2.30	2.16	1.93
45	1.60	1.65	1.80	2.30	2.16	1.94
46	1.61	1.66	1.80	2.30	2.17	1.95
47	1.63	1.68	1.80	2.32	2.18	1.96
48	1.64	1.68	1.80	2.32	2.18	1.96
49	1.65	1.69	1.80	2.32	2.19	1.96
50	1.70	1.70	1.81	2.33	2.19	1.97
51	1.70	1.72	1.84	2.34	2.19	1.97
52	1.71	1.72	1.84	2.34	2.19	1.97
53	1.72	1.73	1.85	2.35	2.20	1.98
54	1.72	1.73	1.86	2.35	2.20	1.99
55	1.74	1.73	1.87	2.36	2.20	1.99
56	1.74	1.73	1.88	2.37	2.20	1.99
57	1.75	1.75	1.88	2.38	2.20	2.01
58	1.77	1.76	1.91	2.40	2.21	2.01
59	1.79	1.76	1.91	2.41	2.22	2.02
60	1.79	1.76	1.91	2.41	2.22	2.03
61	1.80	1.76	1.92	2.41	2.22	2.03
62	1.80	1.77	1.93	2.42	2.22	2.03
63	1.81	1.77	1.93	2.42	2.22	2.03
64	1.81	1.77	1.95	2.42	2.23	2.04
65	1.81	1.77	1.95	2.42	2.23	2.04
66	1.83	1.78	1.96	2.43	2.23	2.04
67	1.83	1.78	1.97	2.43	2.23	2.05
68	1.84	1.78	1.97	2.43	2.23	2.06
69	1.84	1.79	1.97	2.44	2.25	2.06
70	1.84	1.79	1.97	2.44	2.25	2.06
71	1.85	1.79	1.99	2.44	2.26	2.06
72	1.86	1.79	1.99	2.44	2.26	2.06
73	1.88	1.80	1.99	2.45	2.26	2.07
74	1.89	1.80	1.99	2.46	2.27	2.07
75	1.89	1.81	2.01	2.46	2.29	2.09
76	1.89	1.81	2.01	2.47	2.29	2.10
77	1.90	1.82	2.01	2.47	2.30	2.11
78	1.90	1.82	2.01	2.47	2.30	2.12
79	1.91	1.82	2.02	2.47	2.30	2.12
80	1.91	1.82	2.02	2.48	2.31	2.13
81	1.92	1.82	2.03	2.49	2.32	2.15
82	1.92	1.83	2.05	2.49	2.33	2.17
83	1.92	1.84	2.05	2.49	2.34	2.17
84	1.93	1.86	2.06	2.50	2.34	2.18
85	1.93	1.87	2.07	2.51	2.34	2.19
86	1.93	1.87	2.07	2.52	2.34	2.20
87	1.93	1.87	2.09	2.52	2.35	2.20
88	1.93	1.88	2.10	2.54	2.35	2.20
89	1.93	1.88	2.10	2.54	2.35	2.20
90	1.95	1.88	2.11	2.55	2.36	2.20
91	1.95	1.89	2.11	2.55	2.36	2.21
92	1.96	1.89	2.11	2.55	2.36	2.21
93	1.96	1.89	2.11	2.56	2.38	2.21
94	1.96	1.90	2.11	2.56	2.38	2.21
95	1.97	1.93	2.12	2.57	2.38	2.22
96	1.97	1.93	2.12	2.57	2.39	2.23
97	1.97	1.93	2.12	2.58	2.39	2.24
98	1.97	1.94	2.13	2.58	2.39	2.24
99	1.98	1.94	2.13	2.59	2.39	2.24
100	1.98	1.94	2.14	2.59	2.40	2.24
101	1.98	1.94	2.15	2.59	2.42	2.25
102	2.00	1.94	2.16	2.59	2.42	2.26
103	2.01	1.94	2.16	2.62	2.43	2.26
104	2.01	1.94	2.16	2.64	2.43	2.26
105	2.02	1.94	2.16	2.64	2.43	2.26
106	2.03	1.94	2.16	2.65	2.44	2.27
107	2.03	1.95	2.17	2.66	2.44	2.27
108	2.05	1.95	2.17	2.67	2.44	2.27
109	2.05	1.95	2.18	2.67	2.44	2.27
110	2.05	1.95	2.18	2.68	2.45	2.28
111	2.05	1.95	2.18	2.68	2.46	2.29
112	2.06	1.95	2.18	2.69	2.46	2.29
113	2.06	1.97	2.20	2.70	2.47	2.29
114	2.06	1.97	2.20	2.70	2.47	2.30
115	2.07	1.97	2.20	2.71	2.47	2.30
116	2.07	1.97	2.21	2.72	2.49	2.31
117	2.09	1.97	2.22	2.72	2.49	2.32
118	2.10	1.98	2.23	2.72	2.49	2.32
119	2.10	1.98	2.23	2.73	2.49	2.33
120	2.11	1.99	2.24	2.73	2.50	2.33
121	2.11	2.01	2.24	2.73	2.50	2.34
122	2.12	2.01	2.24	2.73	2.50	2.34
123	2.13	2.01	2.24	2.74	2.50	2.34
124	2.13	2.01	2.24	2.74	2.50	2.34
125	2.13	2.02	2.25	2.74	2.51	2.35
126	2.13	2.02	2.26	2.74	2.51	2.35

Table A1.3: cont.

127	2.14	2.03	2.26	2.75	2.52	2.35
128	2.14	2.03	2.27	2.75	2.52	2.36
129	2.14	2.04	2.27	2.75	2.52	2.36
130	2.15	2.04	2.28	2.76	2.53	2.36
131	2.15	2.04	2.28	2.78	2.53	2.36
132	2.17	2.04	2.29	2.79	2.53	2.38
133	2.18	2.05	2.29	2.80	2.53	2.38
134	2.18	2.05	2.30	2.81	2.53	2.38
135	2.18	2.05	2.30	2.81	2.53	2.38
136	2.18	2.06	2.30	2.82	2.53	2.38
137	2.18	2.06	2.31	2.82	2.53	2.38
138	2.20	2.06	2.31	2.83	2.53	2.39
139	2.20	2.06	2.31	2.84	2.54	2.39
140	2.22	2.07	2.31	2.84	2.54	2.39
141	2.22	2.07	2.31	2.85	2.54	2.39
142	2.22	2.08	2.32	2.85	2.55	2.39
143	2.22	2.08	2.33	2.85	2.55	2.40
144	2.22	2.08	2.33	2.85	2.55	2.40
145	2.22	2.08	2.33	2.85	2.55	2.40
146	2.22	2.08	2.33	2.85	2.56	2.41
147	2.22	2.08	2.34	2.85	2.56	2.41
148	2.22	2.09	2.34	2.86	2.56	2.41
149	2.23	2.09	2.35	2.87	2.57	2.42
150	2.23	2.10	2.35	2.87	2.58	2.42
151	2.23	2.11	2.36	2.87	2.59	2.43
152	2.23	2.11	2.37	2.87	2.59	2.43
153	2.23	2.11	2.37	2.87	2.59	2.43
154	2.23	2.11	2.37	2.87	2.60	2.43
155	2.24	2.12	2.38	2.88	2.60	2.44
156	2.24	2.12	2.38	2.89	2.60	2.44
157	2.24	2.12	2.40	2.90	2.60	2.44
158	2.24	2.12	2.40	2.90	2.61	2.44
159	2.24	2.13	2.40	2.92	2.61	2.45
160	2.25	2.13	2.40	2.92	2.61	2.46
161	2.25	2.13	2.40	2.92	2.62	2.47
162	2.25	2.13	2.41	2.95	2.62	2.47
163	2.26	2.14	2.42	2.96	2.63	2.47
164	2.26	2.14	2.42	2.96	2.63	2.48
165	2.27	2.14	2.42	2.97	2.64	2.48
166	2.27	2.14	2.42	2.97	2.64	2.48
167	2.28	2.14	2.42	2.97	2.64	2.48
168	2.28	2.16	2.43	2.97	2.64	2.49
169	2.29	2.16	2.43	2.98	2.65	2.49
170	2.29	2.16	2.43	2.98	2.65	2.49
171	2.29	2.16	2.44	2.99	2.65	2.49
172	2.30	2.17	2.44	3.00	2.66	2.50
173	2.30	2.17	2.44	3.00	2.66	2.50
174	2.31	2.18	2.45	3.00	2.66	2.50
175	2.31	2.18	2.45	3.00	2.67	2.51
176	2.31	2.18	2.45	3.00	2.67	2.51
177	2.31	2.19	2.46	3.00	2.68	2.51
178	2.31	2.19	2.46	3.00	2.69	2.52
179	2.31	2.20	2.46	3.01	2.69	2.52
180	2.32	2.20	2.46	3.01	2.69	2.52
181	2.32	2.20	2.47	3.01	2.70	2.52
182	2.32	2.20	2.47	3.01	2.70	2.52
183	2.32	2.21	2.48	3.02	2.71	2.53
184	2.33	2.21	2.48	3.02	2.71	2.53
185	2.33	2.21	2.49	3.03	2.71	2.53
186	2.34	2.21	2.50	3.03	2.71	2.53
187	2.35	2.21	2.50	3.04	2.72	2.54
188	2.35	2.21	2.50	3.04	2.73	2.54
189	2.35	2.22	2.50	3.05	2.73	2.55
190	2.35	2.23	2.50	3.06	2.73	2.55
191	2.35	2.23	2.50	3.07	2.74	2.55
192	2.35	2.23	2.51	3.08	2.75	2.55
193	2.35	2.24	2.51	3.08	2.75	2.55
194	2.36	2.24	2.52	3.09	2.75	2.56
195	2.36	2.24	2.52	3.10	2.75	2.56
196	2.36	2.24	2.52	3.12	2.76	2.57
197	2.37	2.25	2.53	3.13	2.77	2.57
198	2.37	2.25	2.53	3.13	2.78	2.57
199	2.38	2.26	2.53	3.14	2.78	2.57
200	2.40	2.26	2.53	3.14	2.78	2.57
201	2.40	2.26	2.54	3.14	2.79	2.57
202	2.41	2.26	2.54	3.14	2.79	2.57
203	2.42	2.26	2.55	3.15	2.79	2.57
204	2.43	2.27	2.55	3.15	2.79	2.57
205	2.43	2.27	2.56	3.16	2.80	2.57
206	2.44	2.27	2.56	3.16	2.80	2.58
207	2.44	2.27	2.57	3.16	2.80	2.58
208	2.44	2.27	2.57	3.16	2.81	2.58
209	2.45	2.28	2.57	3.17	2.81	2.58
210	2.45	2.28	2.58	3.17	2.81	2.59
211	2.45	2.28	2.58	3.18	2.81	2.60
212	2.46	2.28	2.58	3.18	2.82	2.60
213	2.47	2.28	2.58	3.19	2.82	2.61
214	2.47	2.29	2.58	3.19	2.83	2.61
215	2.47	2.30	2.58	3.19	2.83	2.61
216	2.48	2.30	2.60	3.19	2.83	2.61
217	2.48	2.30	2.60	3.20	2.83	2.61
218	2.49	2.30	2.60	3.22	2.83	2.62
219	2.49	2.30	2.60	3.23	2.83	2.62
220	2.49	2.30	2.61	3.24	2.83	2.63
221	2.49	2.30	2.63	3.25	2.83	2.63
222	2.50	2.30	2.63	3.25	2.84	2.63
223	2.50	2.31	2.63	3.25	2.85	2.65
224	2.50	2.31	2.64	3.25	2.85	2.65
225	2.51	2.31	2.65	3.25	2.86	2.65
226	2.51	2.31	2.65	3.26	2.86	2.65
227	2.51	2.32	2.66	3.26	2.86	2.65
228	2.51	2.33	2.67	3.26	2.86	2.66
229	2.51	2.33	2.67	3.28	2.86	2.66
230	2.51	2.33	2.67	3.29	2.86	2.66
231	2.51	2.34	2.67	3.30	2.87	2.66
232	2.51	2.34	2.68	3.30	2.87	2.66
233	2.51	2.35	2.68	3.31	2.87	2.66
234	2.52	2.35	2.69	3.31	2.87	2.67
235	2.52	2.35	2.70	3.32	2.88	2.67
236	2.53	2.35	2.70	3.32	2.88	2.68
237	2.53	2.35	2.71	3.32	2.88	2.68
238	2.53	2.35	2.71	3.33	2.89	2.68
239	2.53	2.36	2.71	3.33	2.89	2.68
240	2.54	2.36	2.71	3.33	2.89	2.68
241	2.54	2.36	2.72	3.34	2.90	2.69
242	2.54	2.36	2.72	3.34	2.91	2.69
243	2.54	2.37	2.72	3.35	2.91	2.69
244	2.54	2.37	2.72	3.35	2.91	2.69
245	2.54	2.37	2.72	3.35	2.91	2.69
246	2.54	2.37	2.72	3.36	2.92	2.70
247	2.54	2.37	2.74	3.36	2.92	2.70
248	2.55	2.38	2.74	3.36	2.92	2.70
249	2.55	2.38	2.74	3.37	2.94	2.70
250	2.55	2.38	2.75	3.37	2.96	2.70
251	2.55	2.38	2.76	3.37	2.96	2.71
252	2.56	2.39	2.76	3.37	2.96	2.71
253	2.56	2.39	2.76	3.37	2.97	2.71
254	2.56	2.39	2.76	3.38	2.97	2.71
255	2.57	2.39	2.76	3.38	2.97	2.72
256	2.57	2.40	2.77	3.39	2.97	2.72
257	2.57	2.40	2.77	3.39	2.97	2.72
258	2.57	2.40	2.78	3.39	2.97	2.72
259	2.57	2.40	2.79	3.40	2.97	2.72
260	2.57	2.40	2.79	3.40	2.98	2.72
261	2.57	2.41	2.79	3.40	2.98	2.73
262	2.57	2.42	2.79	3.41	2.98	2.73
263	2.57	2.42	2.79	3.41	2.98	2.73
264	2.58	2.42	2.80	3.42	2.99	2.73
265	2.59	2.43	2.80	3.42	2.99	2.73

Table A1.3: cont.

266	2.59	2.43	2.80	3.42	3.00	2.74
267	2.59	2.43	2.83	3.43	3.00	2.74
268	2.60	2.43	2.83	3.44	3.00	2.74
269	2.60	2.43	2.83	3.44	3.01	2.74
270	2.60	2.43	2.84	3.44	3.01	2.74
271	2.61	2.43	2.84	3.44	3.01	2.75
272	2.61	2.44	2.84	3.45	3.01	2.75
273	2.61	2.44	2.84	3.46	3.03	2.75
274	2.61	2.44	2.85	3.47	3.03	2.75
275	2.61	2.44	2.85	3.47	3.03	2.76
276	2.61	2.44	2.85	3.47	3.03	2.76
277	2.62	2.45	2.85	3.48	3.03	2.77
278	2.62	2.46	2.86	3.48	3.03	2.77
279	2.62	2.46	2.86	3.48	3.04	2.77
280	2.62	2.46	2.86	3.49	3.04	2.77
281	2.63	2.46	2.86	3.49	3.04	2.77
282	2.63	2.46	2.87	3.50	3.06	2.77
283	2.63	2.46	2.87	3.50	3.06	2.78
284	2.63	2.46	2.88	3.50	3.06	2.78
285	2.63	2.47	2.88	3.50	3.06	2.78
286	2.65	2.47	2.88	3.50	3.06	2.79
287	2.65	2.47	2.88	3.50	3.06	2.79
288	2.66	2.47	2.89	3.51	3.06	2.79
289	2.66	2.47	2.89	3.51	3.06	2.79
290	2.66	2.48	2.89	3.51	3.07	2.79
291	2.66	2.48	2.89	3.51	3.07	2.81
292	2.66	2.48	2.90	3.52	3.07	2.82
293	2.67	2.49	2.90	3.52	3.07	2.82
294	2.67	2.49	2.90	3.52	3.07	2.82
295	2.67	2.50	2.90	3.52	3.07	2.82
296	2.67	2.51	2.91	3.53	3.07	2.83
297	2.68	2.51	2.91	3.53	3.07	2.83
298	2.68	2.52	2.92	3.53	3.07	2.83
299	2.68	2.52	2.92	3.54	3.08	2.83
300	2.68	2.53	2.92	3.54	3.08	2.84
301	2.69	2.53	2.92	3.55	3.08	2.84
302	2.69	2.54	2.92	3.55	3.09	2.85
303	2.69	2.54	2.92	3.55	3.09	2.85
304	2.70	2.54	2.92	3.55	3.09	2.85
305	2.70	2.54	2.93	3.55	3.09	2.85
306	2.70	2.54	2.93	3.56	3.10	2.85
307	2.71	2.55	2.94	3.56	3.10	2.85
308	2.71	2.55	2.94	3.57	3.10	2.86
309	2.71	2.55	2.95	3.58	3.10	2.86
310	2.71	2.55	2.95	3.58	3.11	2.86
311	2.72	2.55	2.95	3.58	3.11	2.87
312	2.72	2.55	2.95	3.58	3.12	2.87
313	2.72	2.55	2.95	3.58	3.12	2.88
314	2.72	2.56	2.96	3.59	3.12	2.88
315	2.72	2.56	2.97	3.60	3.12	2.88
316	2.72	2.56	2.99	3.60	3.12	2.88
317	2.72	2.56	3.00	3.60	3.12	2.88
318	2.72	2.56	3.00	3.61	3.12	2.89
319	2.73	2.58	3.00	3.61	3.13	2.89
320	2.73	2.58	3.02	3.62	3.13	2.89
321	2.74	2.58	3.02	3.62	3.13	2.90
322	2.74	2.58	3.02	3.63	3.13	2.90
323	2.74	2.58	3.02	3.63	3.13	2.90
324	2.74	2.58	3.02	3.63	3.14	2.90
325	2.74	2.59	3.02	3.63	3.14	2.91
326	2.75	2.59	3.02	3.63	3.14	2.91
327	2.75	2.59	3.04	3.64	3.14	2.91
328	2.75	2.59	3.04	3.64	3.15	2.91
329	2.75	2.60	3.04	3.65	3.15	2.91
330	2.75	2.60	3.04	3.65	3.16	2.91
331	2.75	2.60	3.05	3.65	3.16	2.92
332	2.75	2.60	3.06	3.65	3.16	2.93
333	2.76	2.60	3.06	3.66	3.17	2.93
334	2.76	2.61	3.08	3.66	3.17	2.93
335	2.76	2.61	3.09	3.66	3.17	2.94
336	2.76	2.62	3.09	3.66	3.18	2.94
337	2.76	2.62	3.09	3.67	3.18	2.94
338	2.77	2.62	3.09	3.67	3.18	2.94
339	2.77	2.63	3.10	3.68	3.18	2.94
340	2.77	2.63	3.10	3.68	3.18	2.94
341	2.78	2.64	3.11	3.68	3.19	2.95
342	2.78	2.65	3.11	3.69	3.19	2.95
343	2.78	2.65	3.12	3.70	3.19	2.95
344	2.78	2.66	3.12	3.70	3.19	2.95
345	2.78	2.66	3.12	3.70	3.19	2.95
346	2.78	2.67	3.12	3.70	3.20	2.96
347	2.79	2.67	3.13	3.70	3.20	2.96
348	2.79	2.68	3.13	3.71	3.20	2.97
349	2.80	2.68	3.14	3.72	3.21	2.97
350	2.80	2.68	3.14	3.72	3.21	2.97
351	2.80	2.68	3.14	3.73	3.21	2.97
352	2.81	2.68	3.15	3.73	3.21	2.97
353	2.81	2.68	3.15	3.73	3.22	2.97
354	2.81	2.69	3.15	3.73	3.22	2.98
355	2.81	2.69	3.15	3.74	3.23	2.98
356	2.81	2.69	3.15	3.75	3.23	2.98
357	2.81	2.69	3.16	3.75	3.23	2.98
358	2.82	2.70	3.16	3.75	3.23	2.98
359	2.82	2.70	3.17	3.76	3.23	2.98
360	2.82	2.71	3.18	3.77	3.23	2.99
361	2.82	2.71	3.18	3.78	3.24	2.99
362	2.82	2.71	3.18	3.78	3.24	3.00
363	2.83	2.71	3.18	3.78	3.24	3.00
364	2.83	2.71	3.18	3.78	3.24	3.00
365	2.83	2.71	3.18	3.79	3.24	3.00
366	2.83	2.71	3.18	3.79	3.25	3.00
367	2.83	2.72	3.19	3.79	3.25	3.01
368	2.84	2.72	3.19	3.79	3.25	3.01
369	2.84	2.72	3.19	3.79	3.25	3.01
370	2.84	2.72	3.19	3.79	3.25	3.02
371	2.84	2.73	3.19	3.80	3.26	3.02
372	2.84	2.73	3.20	3.80	3.27	3.03
373	2.85	2.73	3.20	3.80	3.27	3.03
374	2.85	2.73	3.20	3.80	3.27	3.03
375	2.85	2.74	3.21	3.80	3.27	3.03
376	2.85	2.74	3.21	3.80	3.27	3.03
377	2.85	2.74	3.22	3.80	3.27	3.03
378	2.86	2.75	3.22	3.81	3.28	3.04
379	2.86	2.75	3.23	3.81	3.28	3.04
380	2.87	2.75	3.23	3.81	3.28	3.04
381	2.87	2.75	3.23	3.82	3.28	3.04
382	2.87	2.76	3.23	3.82	3.28	3.04
383	2.87	2.76	3.24	3.82	3.28	3.04
384	2.87	2.77	3.24	3.83	3.29	3.04
385	2.88	2.77	3.24	3.83	3.29	3.04
386	2.88	2.77	3.25	3.84	3.29	3.05
387	2.88	2.77	3.25	3.85	3.29	3.05
388	2.88	2.78	3.26	3.86	3.29	3.05
389	2.88	2.78	3.26	3.86	3.30	3.05
390	2.88	2.78	3.26	3.86	3.30	3.05
391	2.88	2.78	3.26	3.87	3.30	3.05
392	2.89	2.78	3.26	3.87	3.30	3.06
393	2.89	2.78	3.27	3.87	3.30	3.06
394	2.89	2.79	3.27	3.88	3.30	3.07
395	2.90	2.79	3.27	3.89	3.31	3.07
396	2.90	2.79	3.28	3.89	3.31	3.07
397	2.90	2.79	3.28	3.89	3.31	3.07
398	2.91	2.80	3.29	3.90	3.32	3.07
399	2.91	2.80	3.29	3.91	3.32	3.07
400	2.91	2.80	3.29	3.92	3.32	3.08
401	2.91	2.80	3.30	3.92	3.33	3.08
402	2.92	2.80	3.30	3.93	3.33	3.08
403	2.92	2.80	3.30	3.93	3.33	3.08
404	2.92	2.82	3.30	3.94	3.34	3.08

Table A1.3: cont.

405	2.92	2.82	3.31	3.94	3.34	3.08
406	2.93	2.82	3.31	3.94	3.34	3.09
407	2.93	2.82	3.31	3.95	3.34	3.09
408	2.93	2.83	3.31	3.95	3.34	3.09
409	2.93	2.83	3.32	3.95	3.34	3.09
410	2.94	2.83	3.32	3.95	3.34	3.09
411	2.94	2.84	3.32	3.95	3.35	3.09
412	2.94	2.84	3.32	3.96	3.35	3.10
413	2.95	2.84	3.32	3.96	3.35	3.10
414	2.95	2.84	3.32	3.97	3.35	3.10
415	2.95	2.85	3.33	3.97	3.36	3.10
416	2.95	2.85	3.33	3.97	3.36	3.10
417	2.95	2.86	3.33	3.97	3.36	3.10
418	2.96	2.86	3.34	3.98	3.36	3.11
419	2.96	2.86	3.34	3.98	3.36	3.11
420	2.96	2.86	3.35	3.98	3.37	3.11
421	2.96	2.86	3.35	3.99	3.37	3.11
422	2.96	2.86	3.37	3.99	3.37	3.11
423	2.97	2.87	3.38	4.00	3.37	3.12
424	2.98	2.87	3.38	4.00	3.38	3.12
425	2.98	2.87	3.38	4.00	3.38	3.12
426	2.98	2.87	3.38	4.00	3.38	3.13
427	2.98	2.87	3.38	4.01	3.38	3.13
428	2.99	2.88	3.39	4.02	3.38	3.13
429	2.99	2.88	3.40	4.02	3.38	3.13
430	2.99	2.88	3.41	4.03	3.39	3.13
431	2.99	2.88	3.42	4.03	3.39	3.14
432	2.99	2.88	3.42	4.04	3.39	3.14
433	2.99	2.89	3.42	4.05	3.40	3.15
434	2.99	2.89	3.43	4.05	3.40	3.15
435	3.00	2.89	3.43	4.05	3.40	3.15
436	3.00	2.89	3.43	4.05	3.40	3.16
437	3.00	2.90	3.44	4.05	3.41	3.16
438	3.00	2.90	3.44	4.07	3.41	3.16
439	3.01	2.90	3.44	4.07	3.41	3.16
440	3.01	2.90	3.45	4.07	3.41	3.17
441	3.01	2.90	3.45	4.08	3.41	3.18
442	3.02	2.90	3.45	4.08	3.41	3.18
443	3.02	2.90	3.46	4.09	3.42	3.18
444	3.02	2.91	3.47	4.09	3.42	3.18
445	3.03	2.91	3.48	4.10	3.42	3.18
446	3.03	2.91	3.48	4.11	3.42	3.19
447	3.03	2.91	3.48	4.11	3.43	3.19
448	3.03	2.91	3.49	4.11	3.43	3.19
449	3.03	2.92	3.49	4.11	3.43	3.19
450	3.03	2.92	3.49	4.12	3.43	3.19
451	3.03	2.92	3.49	4.12	3.44	3.19
452	3.04	2.92	3.49	4.12	3.45	3.19
453	3.04	2.92	3.50	4.12	3.45	3.19
454	3.04	2.93	3.50	4.12	3.46	3.19
455	3.05	2.94	3.50	4.13	3.46	3.20
456	3.05	2.94	3.50	4.13	3.47	3.20
457	3.05	2.94	3.50	4.14	3.47	3.20
458	3.05	2.95	3.51	4.17	3.48	3.20
459	3.05	2.95	3.52	4.17	3.48	3.20
460	3.05	2.95	3.52	4.17	3.48	3.20
461	3.06	2.96	3.52	4.17	3.49	3.20
462	3.06	2.96	3.52	4.18	3.49	3.20
463	3.07	2.96	3.52	4.18	3.49	3.20
464	3.07	2.96	3.53	4.18	3.49	3.21
465	3.08	2.97	3.53	4.19	3.49	3.21
466	3.08	2.97	3.53	4.19	3.50	3.21
467	3.09	2.97	3.53	4.19	3.50	3.21
468	3.09	2.98	3.54	4.20	3.50	3.21
469	3.09	2.98	3.55	4.20	3.51	3.21
470	3.09	2.98	3.55	4.21	3.52	3.21
471	3.09	2.98	3.56	4.21	3.52	3.22
472	3.10	2.98	3.56	4.21	3.52	3.22
473	3.10	2.99	3.56	4.22	3.52	3.22
474	3.10	2.99	3.57	4.22	3.52	3.22
475	3.10	2.99	3.58	4.22	3.52	3.22
476	3.11	3.00	3.58	4.22	3.53	3.23
477	3.11	3.00	3.58	4.22	3.53	3.23
478	3.11	3.00	3.61	4.22	3.53	3.23
479	3.12	3.00	3.61	4.23	3.54	3.23
480	3.12	3.02	3.61	4.23	3.54	3.23
481	3.13	3.02	3.61	4.23	3.54	3.23
482	3.13	3.02	3.62	4.23	3.57	3.23
483	3.13	3.02	3.62	4.23	3.57	3.23
484	3.13	3.03	3.62	4.25	3.58	3.23
485	3.13	3.03	3.62	4.26	3.58	3.24
486	3.14	3.03	3.63	4.27	3.58	3.24
487	3.14	3.04	3.63	4.27	3.58	3.24
488	3.15	3.04	3.63	4.28	3.58	3.24
489	3.15	3.04	3.64	4.28	3.60	3.24
490	3.15	3.04	3.65	4.29	3.61	3.24
491	3.15	3.04	3.65	4.29	3.62	3.24
492	3.15	3.05	3.65	4.30	3.62	3.25
493	3.16	3.05	3.65	4.30	3.62	3.25
494	3.16	3.05	3.65	4.30	3.62	3.25
495	3.16	3.06	3.66	4.31	3.63	3.25
496	3.16	3.06	3.66	4.31	3.63	3.25
497	3.16	3.06	3.67	4.31	3.63	3.25
498	3.16	3.06	3.68	4.31	3.63	3.26
499	3.17	3.06	3.68	4.32	3.64	3.26
500	3.17	3.06	3.68	4.32	3.64	3.26
501	3.17	3.07	3.69	4.32	3.64	3.26
502	3.17	3.07	3.69	4.34	3.65	3.26
503	3.18	3.07	3.69	4.35	3.65	3.26
504	3.18	3.07	3.69	4.35	3.66	3.26
505	3.19	3.07	3.70	4.36	3.66	3.27
506	3.19	3.08	3.70	4.36	3.66	3.27
507	3.19	3.08	3.70	4.36	3.66	3.27
508	3.19	3.08	3.71	4.37	3.66	3.27
509	3.19	3.08	3.72	4.38	3.66	3.27
510	3.20	3.08	3.72	4.39	3.67	3.27
511	3.20	3.08	3.72	4.39	3.67	3.27
512	3.20	3.09	3.73	4.40	3.68	3.27
513	3.20	3.09	3.74	4.41	3.68	3.28
514	3.20	3.09	3.75	4.42	3.69	3.28
515	3.21	3.11	3.75	4.42	3.69	3.28
516	3.21	3.11	3.75	4.42	3.69	3.28
517	3.21	3.13	3.76	4.42	3.69	3.28
518	3.21	3.13	3.76	4.42	3.69	3.28
519	3.21	3.13	3.78	4.43	3.69	3.28
520	3.22	3.13	3.78	4.43	3.69	3.29
521	3.22	3.14	3.79	4.43	3.70	3.29
522	3.22	3.14	3.79	4.43	3.70	3.29
523	3.22	3.14	3.80	4.44	3.70	3.29
524	3.22	3.15	3.80	4.44	3.70	3.29
525	3.23	3.15	3.81	4.44	3.71	3.30
526	3.23	3.15	3.81	4.44	3.72	3.30
527	3.24	3.15	3.82	4.45	3.72	3.30
528	3.25	3.15	3.82	4.45	3.72	3.30
529	3.25	3.16	3.83	4.45	3.72	3.30
530	3.25	3.17	3.83	4.45	3.72	3.30
531	3.26	3.17	3.84	4.45	3.73	3.30
532	3.26	3.17	3.84	4.46	3.74	3.30
533	3.26	3.17	3.84	4.46	3.74	3.30
534	3.26	3.18	3.84	4.47	3.74	3.30
535	3.26	3.18	3.86	4.48	3.75	3.31
536	3.27	3.18	3.86	4.48	3.75	3.31
537	3.27	3.18	3.87	4.48	3.76	3.31
538	3.27	3.18	3.88	4.49	3.76	3.31
539	3.28	3.19	3.88	4.49	3.77	3.32
540	3.28	3.19	3.88	4.49	3.77	3.32
541	3.29	3.19	3.88	4.49	3.77	3.32
542	3.29	3.19	3.89	4.50	3.77	3.32
543	3.29	3.20	3.91	4.51	3.77	3.32

Table A1.3: cont.

544	3.30	3.20	3.91	4.51	3.77	3.32
545	3.30	3.20	3.92	4.52	3.77	3.33
546	3.30	3.20	3.94	4.52	3.78	3.33
547	3.30	3.21	3.95	4.53	3.78	3.33
548	3.30	3.21	3.96	4.53	3.78	3.33
549	3.30	3.22	3.96	4.53	3.78	3.33
550	3.30	3.22	3.97	4.53	3.78	3.34
551	3.31	3.22	3.98	4.54	3.79	3.34
552	3.32	3.23	3.98	4.54	3.79	3.34
553	3.32	3.23	3.98	4.54	3.80	3.34
554	3.32	3.23	3.98	4.55	3.80	3.35
555	3.33	3.23	3.99	4.55	3.80	3.35
556	3.33	3.23	3.99	4.55	3.80	3.35
557	3.34	3.23	4.00	4.55	3.82	3.35
558	3.34	3.24	4.01	4.56	3.82	3.35
559	3.34	3.24	4.01	4.56	3.83	3.36
560	3.35	3.26	4.03	4.56	3.84	3.36
561	3.36	3.26	4.03	4.57	3.84	3.36
562	3.37	3.27	4.03	4.58	3.84	3.36
563	3.37	3.28	4.03	4.58	3.84	3.37
564	3.37	3.30	4.03	4.58	3.84	3.37
565	3.38	3.30	4.04	4.58	3.85	3.37
566	3.38	3.30	4.04	4.59	3.85	3.37
567	3.38	3.30	4.05	4.59	3.85	3.37
568	3.38	3.30	4.06	4.60	3.85	3.37
569	3.39	3.30	4.07	4.61	3.85	3.37
570	3.39	3.31	4.07	4.61	3.86	3.38
571	3.39	3.32	4.08	4.62	3.86	3.39
572	3.39	3.32	4.08	4.63	3.86	3.39
573	3.39	3.32	4.10	4.63	3.86	3.39
574	3.40	3.32	4.10	4.64	3.86	3.39
575	3.40	3.33	4.10	4.64	3.86	3.39
576	3.40	3.33	4.11	4.64	3.86	3.40
577	3.40	3.33	4.11	4.65	3.87	3.40
578	3.40	3.33	4.12	4.65	3.87	3.41
579	3.41	3.34	4.12	4.66	3.87	3.41
580	3.41	3.35	4.12	4.67	3.88	3.41
581	3.41	3.35	4.13	4.68	3.88	3.41
582	3.42	3.36	4.13	4.68	3.89	3.42
583	3.42	3.36	4.13	4.69	3.89	3.42
584	3.42	3.36	4.14	4.69	3.89	3.43
585	3.42	3.37	4.14	4.70	3.89	3.43
586	3.43	3.39	4.15	4.71	3.90	3.43
587	3.43	3.39	4.15	4.71	3.91	3.43
588	3.43	3.39	4.15	4.72	3.92	3.43
589	3.43	3.41	4.15	4.72	3.92	3.44
590	3.43	3.41	4.15	4.73	3.92	3.44
591	3.43	3.41	4.16	4.73	3.92	3.44
592	3.44	3.42	4.17	4.73	3.92	3.44
593	3.44	3.42	4.18	4.74	3.93	3.44
594	3.44	3.42	4.19	4.74	3.93	3.44
595	3.44	3.42	4.19	4.74	3.93	3.44
596	3.45	3.42	4.19	4.75	3.93	3.44
597	3.45	3.43	4.21	4.76	3.93	3.45
598	3.45	3.44	4.22	4.76	3.94	3.45
599	3.46	3.45	4.22	4.76	3.94	3.45
600	3.46	3.48	4.22	4.76	3.94	3.45
601	3.47	3.49	4.23	4.76	3.94	3.46
602	3.47	3.49	4.23	4.77	3.94	3.46
603	3.47	3.49	4.25	4.77	3.95	3.47
604	3.47	3.49	4.25	4.79	3.95	3.47
605	3.47	3.50	4.26	4.80	3.95	3.47
606	3.47	3.50	4.27	4.84	3.96	3.47
607	3.48	3.50	4.28	4.84	3.96	3.47
608	3.48	3.50	4.31	4.88	3.96	3.48
609	3.48	3.50	4.31	4.89	3.97	3.48
610	3.49	3.51	4.31	4.89	3.97	3.48
611	3.49	3.51	4.32	4.89	3.97	3.48
612	3.49	3.51	4.33	4.91	3.97	3.48
613	3.49	3.51	4.33	4.91	3.97	3.49
614	3.49	3.51	4.33	4.91	3.98	3.49
615	3.50	3.52	4.34	4.92	3.98	3.50
616	3.50	3.52	4.34	4.94	3.98	3.50
617	3.51	3.53	4.35	4.95	3.98	3.50
618	3.51	3.54	4.36	4.97	3.98	3.51
619	3.51	3.54	4.37	4.97	3.99	3.51
620	3.52	3.54	4.38	4.97	3.99	3.52
621	3.53	3.55	4.39	4.98	4.00	3.52
622	3.53	3.57	4.39	4.98	4.00	3.52
623	3.54	3.58	4.40	4.99	4.00	3.52
624	3.54	3.59	4.41	4.99	4.02	3.52
625	3.55	3.61	4.41	5.00	4.02	3.52
626	3.56	3.61	4.42	5.01	4.02	3.53
627	3.56	3.62	4.43	5.03	4.02	3.53
628	3.56	3.62	4.43	5.03	4.02	3.53
629	3.56	3.63	4.43	5.04	4.03	3.53
630	3.57	3.63	4.44	5.04	4.03	3.53
631	3.58	3.65	4.45	5.05	4.03	3.54
632	3.58	3.65	4.46	5.05	4.03	3.54
633	3.59	3.65	4.46	5.06	4.04	3.54
634	3.59	3.67	4.47	5.06	4.04	3.54
635	3.59	3.69	4.47	5.07	4.04	3.55
636	3.59	3.71	4.49	5.10	4.05	3.55
637	3.59	3.71	4.51	5.10	4.06	3.55
638	3.59	3.72	4.51	5.11	4.06	3.55
639	3.59	3.72	4.52	5.11	4.08	3.55
640	3.59	3.72	4.52	5.11	4.08	3.55
641	3.59	3.72	4.52	5.12	4.08	3.55
642	3.60	3.72	4.52	5.13	4.08	3.55
643	3.60	3.73	4.54	5.15	4.09	3.55
644	3.60	3.74	4.58	5.17	4.09	3.56
645	3.61	3.75	4.59	5.18	4.10	3.56
646	3.61	3.76	4.60	5.18	4.10	3.56
647	3.61	3.76	4.60	5.18	4.11	3.56
648	3.61	3.76	4.62	5.18	4.11	3.57
649	3.61	3.77	4.65	5.21	4.11	3.57
650	3.62	3.79	4.65	5.22	4.12	3.57
651	3.62	3.82	4.66	5.23	4.12	3.58
652	3.63	3.82	4.66	5.23	4.12	3.58
653	3.65	3.83	4.67	5.26	4.12	3.58
654	3.66	3.84	4.68	5.26	4.12	3.58
655	3.66	3.85	4.69	5.28	4.13	3.58
656	3.67	3.85	4.70	5.29	4.13	3.58
657	3.67	3.85	4.72	5.29	4.13	3.58
658	3.68	3.86	4.74	5.30	4.14	3.58
659	3.68	3.86	4.74	5.32	4.14	3.59
660	3.68	3.88	4.75	5.33	4.15	3.59
661	3.68	3.88	4.76	5.34	4.15	3.59
662	3.68	3.88	4.77	5.39	4.16	3.59
663	3.69	3.89	4.77	5.39	4.16	3.59
664	3.69	3.90	4.78	5.40	4.16	3.60
665	3.69	3.90	4.78	5.40	4.17	3.60
666	3.70	3.91	4.79	5.40	4.17	3.60
667	3.70	3.91	4.79	5.40	4.17	3.60
668	3.71	3.92	4.80	5.43	4.18	3.60
669	3.71	3.92	4.83	5.45	4.18	3.60
670	3.72	3.92	4.84	5.52	4.18	3.60
671	3.73	3.93	4.85	5.54	4.19	3.60
672	3.73	3.95	4.86	5.55	4.19	3.60
673	3.73	3.95	4.88	5.58	4.20	3.61
674	3.74	3.96	4.88	5.63	4.20	3.61
675	3.74	3.97	4.89	5.63	4.20	3.61
676	3.74	3.97	4.89	5.65	4.22	3.61
677	3.75	3.99	4.89	5.65	4.23	3.61
678	3.75	3.99	4.91	5.66	4.24	3.61
679	3.75	4.02	4.92	5.66	4.24	3.62
680	3.76	4.02	4.94	5.67	4.25	3.63
681	3.77	4.03	4.95	5.70	4.25	3.63
682	3.77	4.04	4.99	5.71	4.25	3.63

Table A1.3: cont.

683	3.77	4.04	4.99	5.75	4.25	3.63
684	3.77	4.05	5.02	5.75	4.25	3.64
685	3.78	4.05	5.05	5.77	4.25	3.64
686	3.78	4.06	5.05	5.77	4.26	3.64
687	3.79	4.09	5.05	5.80	4.26	3.64
688	3.79	4.10	5.06	5.83	4.26	3.64
689	3.80	4.10	5.07	5.85	4.27	3.65
690	3.80	4.10	5.07	5.86	4.28	3.65
691	3.80	4.12	5.08	5.87	4.28	3.65
692	3.80	4.13	5.13	5.87	4.29	3.65
693	3.80	4.14	5.13	5.87	4.30	3.66
694	3.80	4.15	5.18	5.88	4.30	3.66
695	3.81	4.15	5.20	5.89	4.31	3.66
696	3.82	4.15	5.20	5.93	4.32	3.66
697	3.83	4.17	5.21	5.94	4.32	3.66
698	3.83	4.19	5.22	5.96	4.32	3.66
699	3.84	4.19	5.23	6.00	4.32	3.66
700	3.84	4.22	5.23	6.01	4.32	3.66
701	3.84	4.22	5.23	6.02	4.32	3.67
702	3.84	4.23	5.24	6.03	4.33	3.67
703	3.84	4.23	5.25	6.08	4.33	3.67
704	3.85	4.25	5.27	6.10	4.34	3.67
705	3.85	4.25	5.27	6.12	4.34	3.67
706	3.85	4.26	5.28	6.13	4.35	3.68
707	3.85	4.26	5.29	6.17	4.36	3.68
708	3.85	4.28	5.29	6.17	4.36	3.68
709	3.86	4.28	5.29	6.17	4.37	3.68
710	3.88	4.28	5.31	6.19	4.37	3.69
711	3.88	4.28	5.33	6.19	4.38	3.69
712	3.89	4.31	5.34	6.22	4.38	3.70
713	3.90	4.31	5.34	6.22	4.38	3.70
714	3.90	4.32	5.38	6.27	4.39	3.70
715	3.91	4.32	5.41	6.34	4.40	3.70
716	3.91	4.33	5.42	6.38	4.42	3.71
717	3.91	4.34	5.43	6.39	4.42	3.71
718	3.92	4.34	5.44	6.39	4.42	3.71
719	3.92	4.37	5.45	6.41	4.44	3.71
720	3.94	4.38	5.50	6.41	4.44	3.71
721	3.95	4.38	5.50	6.43	4.44	3.71
722	3.95	4.40	5.51	6.52	4.44	3.71
723	3.96	4.41	5.63	6.62	4.44	3.71
724	3.96	4.41	5.64	6.64	4.44	3.72
725	3.96	4.42	5.65	6.66	4.44	3.72
726	3.96	4.44	5.66	6.71	4.45	3.72
727	3.96	4.46	5.70	6.74	4.45	3.72
728	3.97	4.47	5.74	6.87	4.45	3.73
729	4.00	4.47	5.78	6.93	4.46	3.73
730	4.00	4.48	5.84	6.98	4.46	3.73
731	4.01	4.52	5.86	7.03	4.46	3.73
732	4.01	4.54	5.87	7.04	4.46	3.73
733	4.01	4.55	5.92	7.05	4.49	3.73
734	4.02	4.60	5.98	7.07	4.50	3.73
735	4.03	4.61	6.03	7.25	4.50	3.73
736	4.03	4.63	6.17	7.27	4.50	3.73
737	4.04	4.64	6.22	7.29	4.51	3.74
738	4.04	4.65	6.25	7.62	4.51	3.75
739	4.05	4.67	6.30	7.62	4.52	3.75
740	4.06	4.67	6.34	7.71	4.52	3.75
741	4.07	4.69	6.34	7.78	4.52	3.75
742	4.07	4.74	6.40	7.92	4.52	3.75
743	4.07	4.75	6.41	7.93	4.53	3.76
744	4.08	4.76	6.42	8.03	4.54	3.76
745	4.09	4.80	6.45	8.18	4.55	3.76
746	4.11	4.80	6.51	9.29	4.56	3.76
747	4.12	4.86	6.56	9.46	4.57	3.76
748	4.12	4.87	6.57	9.69	4.57	3.77
749	4.13	4.98	6.62	10.05	4.57	3.77
750	4.13	5.00	6.68	10.13	4.58	3.77
751	4.13	5.01	7.11	10.16	4.58	3.78
752	4.15	5.02	7.20	10.98	4.59	3.78
753	4.17	5.02	7.30	11.04	4.60	3.78
754	4.17	5.08	7.36	11.44	4.60	3.78
755	4.18	5.16	7.36	13.00	4.61	3.78
756	4.18	5.16	7.49	15.95	4.62	3.79
757	4.18	5.19	7.59	19.35	4.62	3.79
758	4.21	5.20	7.60	21.36	4.62	3.79
759	4.21	5.21	7.67	30.03	4.64	3.79
760	4.22	5.24	7.79	35.84	4.64	3.80
761	4.22	5.27	7.83	35.90	4.66	3.80
762	4.22	5.28	7.87		4.66	3.80
763	4.23	5.31	8.03		4.66	3.81
764	4.24	5.32	8.04		4.66	3.81
765	4.25	5.35	8.50		4.67	3.81
766	4.26	5.41	8.59		4.67	3.81
767	4.27	5.43	8.64		4.67	3.81
768	4.27	5.45	8.77		4.67	3.81
769	4.27	5.54	8.89		4.68	3.81
770	4.28	5.68	9.49		4.69	3.82
771	4.28	5.78	9.81		4.69	3.82
772	4.30	5.81	10.70		4.69	3.82
773	4.30	6.03	10.83		4.69	3.83
774	4.31	6.14	10.88		4.70	3.83
775	4.31	6.18	12.61		4.70	3.83
776	4.33	6.19	14.65		4.70	3.83
777	4.33	6.22	25.78		4.70	3.84
778	4.34	6.35	26.82		4.71	3.84
779	4.34	6.49	30.07		4.72	3.84
780	4.35	7.01	30.48		4.72	3.85
781	4.36	7.11	33.43		4.73	3.85
782	4.36	7.52	33.95		4.73	3.85
783	4.36	7.56	34.94		4.74	3.85
784	4.37	8.28	35.81		4.74	3.85
785	4.37	8.41	39.74		4.74	3.85
786	4.38	8.54			4.74	3.86
787	4.39	8.83			4.74	3.86
788	4.40	8.90			4.75	3.86
789	4.40	9.46			4.75	3.86
790	4.40	9.90			4.76	3.86
791	4.41	11.95			4.76	3.87
792	4.41	15.05			4.77	3.87
793	4.41	15.29			4.77	3.87
794	4.41	16.82			4.78	3.87
795	4.42	23.67			4.78	3.88
796	4.42	26.17			4.79	3.88
797	4.43	27.43			4.79	3.89
798	4.44	27.55			4.79	3.89
799	4.45	33.36			4.82	3.89
800	4.46	39.26			4.82	3.89
801	4.47				4.82	3.89
802	4.47				4.84	3.90
803	4.48				4.84	3.90
804	4.48				4.85	3.90
805	4.48				4.85	3.90
806	4.49				4.85	3.90
807	4.50				4.86	3.91
808	4.50				4.86	3.91
809	4.51				4.86	3.91
810	4.51				4.87	3.91
811	4.52				4.87	3.91
812	4.52				4.88	3.91
813	4.52				4.89	3.91
814	4.53				4.90	3.91
815	4.55				4.91	3.92
816	4.55				4.91	3.92
817	4.57				4.91	3.92
818	4.58				4.92	3.92
819	4.58				4.94	3.92
820	4.58				4.96	3.93
821	4.59				4.97	3.93

Table A1.3: cont.

822	4.59				4.99	3.93
823	4.62				5.00	3.93
824	4.63				5.00	3.94
825	4.65				5.01	3.94
826	4.66				5.02	3.94
827	4.69				5.03	3.95
828	4.69				5.04	3.95
829	4.71				5.04	3.95
830	4.72				5.04	3.96
831	4.72				5.06	3.96
832	4.73				5.06	3.96
833	4.73				5.07	3.97
834	4.74				5.07	3.97
835	4.79				5.07	3.97
836	4.80				5.09	3.97
837	4.83				5.09	3.97
838	4.84				5.11	3.98
839	4.84				5.11	3.98
840	4.85				5.12	3.98
841	4.92				5.12	3.98
842	4.92				5.13	3.98
843	4.94				5.14	3.98
844	4.95				5.15	3.99
845	4.95				5.16	4.00
846	4.97				5.18	4.00
847	4.98				5.18	4.00
848	4.98				5.19	4.00
849	4.98				5.21	4.00
850	4.98				5.23	4.00
851	4.98				5.25	4.01
852	5.02				5.25	4.01
853	5.03				5.25	4.01
854	5.04				5.27	4.02
855	5.05				5.28	4.02
856	5.07				5.31	4.03
857	5.07				5.32	4.03
858	5.09				5.32	4.04
859	5.09				5.33	4.05
860	5.09				5.34	4.05
861	5.10				5.36	4.05
862	5.14				5.36	4.05
863	5.16				5.37	4.06
864	5.16				5.39	4.06
865	5.20				5.39	4.06
866	5.20				5.40	4.07
867	5.24				5.41	4.07
868	5.25				5.42	4.08
869	5.26				5.43	4.08
870	5.31				5.43	4.08
871	5.32				5.46	4.08
872	5.32				5.49	4.08
873	5.32				5.51	4.08
874	5.38				5.53	4.09
875	5.39				5.54	4.10
876	5.42				5.55	4.11
877	5.43				5.55	4.11
878	5.44				5.55	4.11
879	5.46				5.56	4.12
880	5.46				5.64	4.12
881	5.46				5.65	4.12
882	5.50				5.71	4.12
883	5.52				5.75	4.12
884	5.54				5.78	4.12
885	5.58				5.78	4.13
886	5.64				5.81	4.13
887	5.65				5.84	4.13
888	5.66				5.86	4.14
889	5.67				5.89	4.14
890	5.67				5.91	4.14
891	5.67				5.94	4.14
892	5.68				6.02	4.14
893	5.70				6.03	4.14
894	5.71				6.03	4.15
895	5.80				6.03	4.15
896	5.86				6.07	4.15
897	5.88				6.11	4.16
898	5.90				6.12	4.16
899	5.92				6.14	4.16
900	5.94				6.16	4.16
901	6.04				6.27	4.16
902	6.06				6.27	4.16
903	6.08				6.37	4.17
904	6.13				6.38	4.17
905	6.16				6.41	4.17
906	6.17				6.41	4.17
907	6.22				6.44	4.18
908	6.25				6.47	4.18
909	6.28				6.51	4.18
910	6.32				6.52	4.18
911	6.49				6.54	4.18
912	6.56				6.54	4.18
913	6.62				6.56	4.19
914	6.63				6.59	4.19
915	6.65				6.65	4.19
916	6.70				6.68	4.20
917	6.71				6.73	4.20
918	6.72				6.79	4.21
919	6.79				6.80	4.21
920	6.82				6.88	4.21
921	6.82				6.93	4.22
922	7.12				6.97	4.22
923	7.17				7.01	4.22
924	7.30				7.06	4.23
925	7.35				7.07	4.23
926	7.35				7.13	4.23
927	7.45				7.16	4.23
928	7.68				7.22	4.24
929	7.90				7.38	4.24
930	8.20				7.43	4.24
931	9.08				7.43	4.25
932	9.22				7.75	4.25
933	10.22				7.81	4.25
934	10.55				7.82	4.25
935	10.62				7.82	4.26
936	11.12				7.87	4.26
937	12.49				8.20	4.26
938	13.56				8.26	4.27
939	14.87				8.34	4.27
940	15.03				8.57	4.28
941	15.62				9.05	4.28
942	15.97				9.05	4.28
943	16.06				9.22	4.28
944	23.91				9.26	4.28
945	24.04				9.26	4.28
946	28.00				9.55	4.29
947	33.90				11.19	4.29
948					12.38	4.29
949					13.32	4.29
950					36.14	4.30
951					48.87	4.30
952					48.87	4.30
953					51.88	4.31
954					57.04	4.31
955						4.31
956						4.31
957						4.31
958						4.32
959						4.32
960						4.32

Table A1.3: cont.

961						4.33
962						4.33
963						4.33
964						4.33
965						4.33
966						4.33
967						4.33
968						4.34
969						4.34
970						4.35
971						4.35
972						4.35
973						4.35
974						4.35
975						4.35
976						4.35
977						4.36
978						4.36
979						4.37
980						4.37
981						4.37
982						4.37
983						4.37
984						4.37
985						4.37
986						4.38
987						4.38
988						4.38
989						4.38
990						4.38
991						4.39
992						4.39
993						4.40
994						4.40
995						4.40
996						4.40
997						4.40
998						4.40
999						4.40
1000						4.41
1001						4.42
1002						4.42
1003						4.43
1004						4.43
1005						4.43
1006						4.43
1007						4.43
1008						4.43
1009						4.43
1010						4.43
1011						4.44
1012						4.44
1013						4.44
1014						4.44
1015						4.45
1016						4.46
1017						4.46
1018						4.47
1019						4.47
1020						4.47
1021						4.48
1022						4.48
1023						4.48
1024						4.49
1025						4.49
1026						4.50
1027						4.50
1028						4.50
1029						4.51
1030						4.51
1031						4.51
1032						4.52
1033						4.53
1034						4.53
1035						4.53
1036						4.54
1037						4.54
1038						4.54
1039						4.55
1040						4.55
1041						4.56
1042						4.57
1043						4.57
1044						4.57
1045						4.57
1046						4.57
1047						4.58
1048						4.58
1049						4.59
1050						4.59
1051						4.61
1052						4.61
1053						4.61
1054						4.61
1055						4.63
1056						4.63
1057						4.63
1058						4.63
1059						4.63
1060						4.63
1061						4.65
1062						4.65
1063						4.65
1064						4.66
1065						4.66
1066						4.66
1067						4.66
1068						4.67
1069						4.67
1070						4.68
1071						4.68
1072						4.69
1073						4.70
1074						4.70
1075						4.70
1076						4.71
1077						4.71
1078						4.72
1079						4.72
1080						4.74
1081						4.74
1082						4.75
1083						4.75
1084						4.77
1085						4.78
1086						4.78
1087						4.78
1088						4.78
1089						4.79
1090						4.79
1091						4.79
1092						4.79
1093						4.80
1094						4.80
1095						4.80
1096						4.80
1097						4.80
1098						4.81
1099						4.81

Table A1.3: cont.

1100						4.82
1101						4.82
1102						4.82
1103						4.82
1104						4.83
1105						4.83
1106						4.83
1107						4.84
1108						4.84
1109						4.84
1110						4.85
1111						4.85
1112						4.85
1113						4.86
1114						4.86
1115						4.87
1116						4.87
1117						4.88
1118						4.89
1119						4.89
1120						4.90
1121						4.90
1122						4.91
1123						4.91
1124						4.91
1125						4.92
1126						4.92
1127						4.92
1128						4.92
1129						4.93
1130						4.93
1131						4.94
1132						4.95
1133						4.95
1134						4.96
1135						4.96
1136						4.97
1137						4.97
1138						4.98
1139						4.98
1140						4.98
1141						4.99
1142						4.99
1143						5.00
1144						5.01
1145						5.01
1146						5.02
1147						5.02
1148						5.03
1149						5.03
1150						5.03
1151						5.04
1152						5.04
1153						5.04
1154						5.05
1155						5.05
1156						5.05
1157						5.06
1158						5.06
1159						5.07
1160						5.07
1161						5.07
1162						5.08
1163						5.09
1164						5.09
1165						5.09
1166						5.11
1167						5.13
1168						5.13
1169						5.13
1170						5.14
1171						5.14
1172						5.14
1173						5.14
1174						5.17
1175						5.18
1176						5.18
1177						5.18
1178						5.18
1179						5.20
1180						5.20
1181						5.20
1182						5.20
1183						5.21
1184						5.21
1185						5.22
1186						5.22
1187						5.25
1188						5.25
1189						5.27
1190						5.27
1191						5.27
1192						5.28
1193						5.29
1194						5.30
1195						5.30
1196						5.31
1197						5.32
1198						5.33
1199						5.34
1200						5.34
1201						5.35
1202						5.35
1203						5.37
1204						5.39
1205						5.39
1206						5.40
1207						5.41
1208						5.41
1209						5.42
1210						5.42
1211						5.43
1212						5.44
1213						5.45
1214						5.45
1215						5.46
1216						5.47
1217						5.47
1218						5.47
1219						5.48
1220						5.49
1221						5.51
1222						5.53
1223						5.53
1224						5.55
1225						5.55
1226						5.55
1227						5.55
1228						5.56
1229						5.57
1230						5.57
1231						5.58
1232						5.58
1233						5.59
1234						5.61
1235						5.61
1236						5.64
1237						5.65
1238						5.65

Table A1.3: cont.

1239						5.66
1240						5.68
1241						5.68
1242						5.71
1243						5.71
1244						5.73
1245						5.73
1246						5.75
1247						5.76
1248						5.77
1249						5.79
1250						5.82
1251						5.82
1252						5.83
1253						5.83
1254						5.83
1255						5.84
1256						5.85
1257						5.86
1258						5.87
1259						5.87
1260						5.90
1261						5.92
1262						5.93
1263						5.93
1264						5.95
1265						5.96
1266						5.97
1267						5.97
1268						5.97
1269						5.98
1270						5.99
1271						5.99
1272						5.99
1273						5.99
1274						6.00
1275						6.01
1276						6.02
1277						6.08
1278						6.12
1279						6.15
1280						6.16
1281						6.19
1282						6.21
1283						6.21
1284						6.22
1285						6.22
1286						6.25
1287						6.27
1288						6.27
1289						6.32
1290						6.34
1291						6.36
1292						6.36
1293						6.37
1294						6.39
1295						6.39
1296						6.40
1297						6.44
1298						6.46
1299						6.48
1300						6.51
1301						6.51
1302						6.52
1303						6.58
1304						6.68
1305						6.68
1306						6.73
1307						6.75
1308						6.76
1309						6.79
1310						6.83
1311						6.83
1312						6.87
1313						6.91
1314						6.91
1315						6.95
1316						6.98
1317						7.00
1318						7.05
1319						7.10
1320						7.34
1321						7.35
1322						7.41
1323						7.60
1324						7.60
1325						7.61
1326						7.69
1327						7.71
1328						7.95
1329						7.96
1330						8.03
1331						8.06
1332						8.27
1333						8.44
1334						8.45
1335						8.54
1336						8.56
1337						8.61
1338						8.73
1339						8.98
1340						9.19
1341						9.25
1342						9.67
1343						9.82
1344						9.87
1345						10.56
1346						10.65
1347						11.35
1348						13.56
1349						14.29
1350						64.00

Appendix A2 - Equivalent Bubble Size Measurements for the Air/Water/0.5% Copy Paper System

This appendix tabulates the equivalent bubble diameter measurements recorded for the air/water/0.5% copy paper system flowing through the cocurrent bubble column. Table A2.1 summarizes the equivalent bubble diameter number density for all bubble diameters. Table A2.2 tabulates the equivalent bubble diameter number density for all data with $d \leq 12$ mm. Table A2.3 presents all of the equivalent bubble diameter measurements obtained from the FXR images.

Table A2.1: Summary of the equivalent bubble diameter number density for all the air/water/0.5% copy paper data obtained in this study.

Copy Paper Consistency (%)	0.5	0.5	0.5	0.5	0.5	0.5
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
$0 < d \leq 1$	0.0	0.0	0.0	0.0	0.0	0.1
$1 < d \leq 1.5$	6.9	3.3	3.0	4.4	2.4	5.3
$1.5 < d \leq 2$	12.1	7.7	6.6	10.9	12.5	8.6
$2 < d \leq 2.5$	15.4	12.5	9.7	15.0	13.3	12.9
$2.5 < d \leq 3$	15.6	17.9	13.5	14.2	16.0	13.1
$3 < d \leq 3.5$	15.0	15.6	15.2	13.6	12.3	13.7
$3.5 < d \leq 4$	11.9	15.0	13.5	12.5	11.8	10.5
$4 < d \leq 4.5$	8.0	9.4	10.3	8.7	7.9	7.7
$4.5 < d \leq 5$	4.9	5.7	9.0	7.0	7.2	7.7
$5 < d \leq 5.5$	2.6	3.6	5.9	3.3	4.7	6.3
$5.5 < d \leq 6$	1.8	2.7	3.2	3.2	2.7	3.6
$6 < d \leq 6.5$	1.7	1.8	2.8	2.7	3.0	2.1
$6.5 < d \leq 7$	0.9	0.9	1.5	1.5	1.1	1.5
$7 < d \leq 7.5$	0.4	1.3	1.0	0.3	1.4	1.7
$7.5 < d \leq 8$	0.7	0.1	0.4	0.3	0.9	1.2
$8 < d \leq 8.5$	0.2	0.4	0.7	0.4	0.2	0.6
$8.5 < d \leq 9$	0.2	0.3	0.3	0.0	0.5	0.7
$9 < d \leq 9.5$	0.2	0.3	0.4	0.3	0.2	0.5
$9.5 < d \leq 10$	0.1	0.0	0.5	0.0	0.3	0.3
$10 < d \leq 10.5$	0.1	0.0	0.1	0.4	0.1	0.1
$10.5 < d \leq 11$	0.0	0.2	0.1	0.0	0.3	0.2
$11 < d \leq 11.5$	0.1	0.0	0.0	0.0	0.0	0.1
$11.5 < d \leq 12$	0.0	0.1	0.0	0.3	0.0	0.0
$d > 12$	1.2	1.4	2.2	1.2	1.3	1.5

Table A2.2: Summary of the equivalent bubble diameter number density for the d ≤ 12 mm air/water/0.5% copy paper data obtained in this study.

Copy Paper Consistency (%)	0.5	0.5	0.5	0.5	0.5	0.5
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
$0 < d \leq 1$	0.0	0.0	0.0	0.0	0.0	0.1
$1 < d \leq 1.5$	7.0	3.4	3.1	4.4	2.4	5.4
$1.5 < d \leq 2$	12.3	7.8	6.7	11.0	12.7	8.7
$2 < d \leq 2.5$	15.5	12.7	9.9	15.2	13.4	13.1
$2.5 < d \leq 3$	15.8	18.2	13.8	14.4	16.2	13.3
$3 < d \leq 3.5$	15.2	15.8	15.5	13.7	12.5	13.9
$3.5 < d \leq 4$	12.0	15.3	13.8	12.7	11.9	10.6
$4 < d \leq 4.5$	8.1	9.5	10.6	8.8	8.0	7.8
$4.5 < d \leq 5$	5.0	5.8	9.2	7.1	7.3	7.8
$5 < d \leq 5.5$	2.6	3.7	6.0	3.4	4.8	6.4
$5.5 < d \leq 6$	1.8	2.7	3.3	3.2	2.7	3.7
$6 < d \leq 6.5$	1.7	1.8	2.9	2.7	3.0	2.1
$6.5 < d \leq 7$	0.9	0.9	1.6	1.6	1.1	1.5
$7 < d \leq 7.5$	0.5	1.3	1.0	0.3	1.4	1.8
$7.5 < d \leq 8$	0.7	0.1	0.4	0.3	0.9	1.2
$8 < d \leq 8.5$	0.2	0.4	0.7	0.4	0.2	0.6
$8.5 < d \leq 9$	0.2	0.3	0.3	0.0	0.5	0.7
$9 < d \leq 9.5$	0.2	0.3	0.4	0.3	0.2	0.5
$9.5 < d \leq 10$	0.1	0.0	0.5	0.0	0.3	0.4
$10 < d \leq 10.5$	0.1	0.0	0.1	0.4	0.1	0.1
$10.5 < d \leq 11$	0.0	0.2	0.1	0.0	0.3	0.2
$11 < d \leq 11.5$	0.1	0.0	0.0	0.0	0.0	0.1
$11.5 < d \leq 12$	0.0	0.1	0.0	0.3	0.0	0.0

Table A2.3: Equivalent bubble diameter data for the air/water/0.5% copy paper system flowing through the cocurrent bubble column. The data are sorted by bubble size.

Copy Paper Consistency (%)	0.5	0.5	0.5	0.5	0.5	0.5
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Count	Equivalent Bubble Diameter (mm)					
1	1.01	1.02	1.01	1.04	1.08	1.00
2	1.01	1.09	1.04	1.11	1.18	1.03
3	1.03	1.09	1.07	1.19	1.28	1.03
4	1.04	1.12	1.07	1.20	1.33	1.05
5	1.04	1.15	1.07	1.21	1.35	1.08
6	1.05	1.15	1.08	1.26	1.36	1.11
7	1.05	1.19	1.09	1.28	1.36	1.12
8	1.07	1.19	1.11	1.28	1.36	1.15
9	1.08	1.24	1.11	1.29	1.37	1.15
10	1.09	1.24	1.16	1.32	1.37	1.16
11	1.09	1.24	1.16	1.32	1.37	1.17
12	1.10	1.27	1.18	1.32	1.39	1.18
13	1.11	1.27	1.21	1.33	1.42	1.19
14	1.13	1.32	1.21	1.33	1.43	1.21
15	1.14	1.33	1.28	1.35	1.44	1.21
16	1.14	1.35	1.30	1.35	1.45	1.23
17	1.17	1.35	1.34	1.36	1.45	1.25
18	1.17	1.35	1.36	1.36	1.45	1.26
19	1.20	1.36	1.37	1.36	1.47	1.27
20	1.21	1.37	1.38	1.36	1.47	1.27
21	1.22	1.37	1.38	1.36	1.48	1.27
22	1.22	1.37	1.40	1.36	1.49	1.27
23	1.22	1.39	1.42	1.37	1.50	1.28
24	1.24	1.39	1.42	1.38	1.50	1.29
25	1.24	1.39	1.42	1.38	1.50	1.29
26	1.24	1.41	1.44	1.39	1.52	1.29
27	1.26	1.44	1.44	1.40	1.52	1.31
28	1.27	1.44	1.46	1.40	1.52	1.35
29	1.28	1.45	1.47	1.44	1.55	1.37
30	1.28	1.45	1.49	1.44	1.55	1.39
31	1.28	1.46	1.50	1.44	1.56	1.39
32	1.29	1.46	1.50	1.47	1.57	1.39
33	1.30	1.46	1.51	1.49	1.57	1.40
34	1.30	1.46	1.53	1.50	1.57	1.40
35	1.30	1.47	1.53	1.50	1.58	1.41
36	1.31	1.48	1.55	1.50	1.58	1.43
37	1.31	1.50	1.55	1.51	1.58	1.43
38	1.32	1.51	1.56	1.51	1.58	1.45
39	1.33	1.52	1.57	1.51	1.60	1.45
40	1.33	1.52	1.57	1.51	1.60	1.45
41	1.33	1.54	1.57	1.53	1.60	1.45
42	1.34	1.55	1.58	1.53	1.60	1.45
43	1.36	1.57	1.58	1.53	1.60	1.46
44	1.37	1.57	1.58	1.54	1.60	1.47
45	1.38	1.57	1.59	1.54	1.61	1.48
46	1.38	1.58	1.60	1.54	1.61	1.48
47	1.40	1.58	1.60	1.55	1.62	1.49
48	1.41	1.58	1.61	1.56	1.62	1.50
49	1.43	1.59	1.62	1.57	1.62	1.52
50	1.44	1.59	1.63	1.57	1.63	1.54
51	1.45	1.60	1.65	1.59	1.63	1.55
52	1.47	1.61	1.66	1.61	1.63	1.55
53	1.48	1.61	1.66	1.62	1.64	1.55
54	1.48	1.62	1.66	1.62	1.65	1.55
55	1.48	1.63	1.66	1.63	1.65	1.56
56	1.49	1.64	1.67	1.63	1.65	1.59
57	1.49	1.64	1.68	1.65	1.66	1.60
58	1.49	1.64	1.68	1.66	1.67	1.61
59	1.49	1.66	1.71	1.66	1.67	1.61
60	1.50	1.66	1.73	1.66	1.68	1.61
61	1.50	1.67	1.74	1.67	1.68	1.61
62	1.50	1.68	1.75	1.68	1.68	1.62
63	1.50	1.69	1.75	1.70	1.68	1.62
64	1.50	1.70	1.75	1.70	1.68	1.63
65	1.51	1.71	1.76	1.70	1.68	1.63
66	1.51	1.71	1.76	1.71	1.68	1.64
67	1.52	1.71	1.76	1.71	1.69	1.65
68	1.53	1.71	1.79	1.71	1.69	1.65
69	1.53	1.72	1.80	1.72	1.70	1.66
70	1.54	1.73	1.82	1.73	1.70	1.66
71	1.54	1.73	1.84	1.73	1.70	1.68
72	1.54	1.75	1.86	1.73	1.71	1.68
73	1.54	1.75	1.87	1.74	1.71	1.69
74	1.55	1.75	1.87	1.74	1.72	1.69
75	1.55	1.76	1.88	1.75	1.72	1.69
76	1.55	1.76	1.90	1.77	1.73	1.71
77	1.56	1.76	1.91	1.77	1.73	1.71
78	1.56	1.77	1.91	1.78	1.73	1.71
79	1.56	1.77	1.92	1.78	1.73	1.72
80	1.56	1.77	1.92	1.80	1.73	1.72
81	1.58	1.78	1.92	1.83	1.73	1.72
82	1.58	1.78	1.93	1.83	1.73	1.73
83	1.58	1.79	1.93	1.84	1.74	1.73
84	1.59	1.80	1.93	1.84	1.75	1.74
85	1.59	1.80	1.93	1.85	1.75	1.74
86	1.63	1.80	1.95	1.85	1.75	1.75
87	1.63	1.81	1.96	1.85	1.76	1.75
88	1.63	1.83	1.97	1.85	1.76	1.75
89	1.65	1.83	1.97	1.85	1.77	1.77
90	1.65	1.83	1.98	1.85	1.77	1.78
91	1.65	1.84	1.98	1.85	1.78	1.78
92	1.67	1.84	1.98	1.87	1.79	1.79
93	1.67	1.84	1.99	1.87	1.80	1.79
94	1.71	1.85	1.99	1.88	1.82	1.79
95	1.71	1.87	2.00	1.88	1.83	1.80
96	1.71	1.87	2.01	1.89	1.83	1.80
97	1.71	1.87	2.02	1.89	1.84	1.81
98	1.71	1.88	2.02	1.89	1.85	1.82
99	1.72	1.88	2.04	1.89	1.85	1.82
100	1.72	1.89	2.04	1.90	1.85	1.82
101	1.73	1.89	2.05	1.90	1.86	1.83
102	1.74	1.89	2.05	1.90	1.86	1.83
103	1.74	1.89	2.05	1.92	1.86	1.84
104	1.75	1.89	2.06	1.92	1.86	1.84
105	1.75	1.89	2.06	1.92	1.86	1.85
106	1.77	1.90	2.06	1.93	1.86	1.86
107	1.77	1.90	2.07	1.94	1.86	1.87
108	1.77	1.91	2.08	1.94	1.88	1.87
109	1.77	1.91	2.08	1.95	1.88	1.89
110	1.78	1.91	2.08	1.96	1.88	1.92
111	1.78	1.93	2.11	1.96	1.89	1.92
112	1.79	1.94	2.12	1.97	1.89	1.93
113	1.80	1.97	2.12	1.98	1.89	1.93
114	1.82	1.97	2.14	1.98	1.89	1.94
115	1.82	1.97	2.16	1.98	1.89	1.95
116	1.82	1.98	2.16	1.99	1.89	1.96
117	1.83	1.99	2.18	1.99	1.90	1.98
118	1.83	1.99	2.18	2.00	1.90	1.98
119	1.83	1.99	2.18	2.00	1.90	1.99
120	1.84	2.00	2.19	2.00	1.91	1.99
121	1.85	2.00	2.19	2.01	1.91	1.99
122	1.85	2.00	2.20	2.01	1.91	2.00
123	1.85	2.00	2.20	2.02	1.92	2.00
124	1.86	2.01	2.20	2.02	1.92	2.01
125	1.86	2.01	2.20	2.03	1.92	2.01
126	1.86	2.01	2.20	2.03	1.93	2.01

Table A2.3: cont.

127	1.87	2.01	2.22	2.03	1.93	2.01
128	1.87	2.02	2.22	2.03	1.93	2.02
129	1.88	2.02	2.22	2.03	1.94	2.02
130	1.90	2.05	2.23	2.04	1.95	2.02
131	1.90	2.05	2.23	2.05	1.95	2.02
132	1.90	2.05	2.23	2.05	1.96	2.03
133	1.90	2.05	2.23	2.05	1.96	2.04
134	1.90	2.06	2.25	2.05	1.96	2.06
135	1.90	2.06	2.26	2.06	1.97	2.07
136	1.92	2.07	2.26	2.07	1.97	2.07
137	1.93	2.07	2.26	2.07	1.98	2.07
138	1.93	2.10	2.26	2.07	2.00	2.07
139	1.93	2.10	2.27	2.08	2.00	2.08
140	1.93	2.12	2.28	2.08	2.00	2.09
141	1.93	2.12	2.28	2.08	2.01	2.09
142	1.93	2.13	2.29	2.08	2.01	2.09
143	1.93	2.13	2.29	2.10	2.02	2.10
144	1.93	2.13	2.29	2.10	2.02	2.10
145	1.94	2.13	2.32	2.12	2.02	2.11
146	1.94	2.13	2.32	2.12	2.03	2.11
147	1.94	2.14	2.33	2.12	2.04	2.11
148	1.95	2.14	2.33	2.12	2.05	2.11
149	1.95	2.15	2.33	2.12	2.05	2.11
150	1.95	2.15	2.33	2.13	2.05	2.12
151	1.95	2.15	2.34	2.14	2.06	2.12
152	1.95	2.15	2.34	2.14	2.06	2.12
153	1.95	2.16	2.34	2.15	2.06	2.13
154	1.95	2.16	2.34	2.15	2.06	2.15
155	1.95	2.16	2.36	2.16	2.06	2.15
156	1.96	2.17	2.36	2.16	2.06	2.15
157	1.96	2.17	2.37	2.16	2.07	2.16
158	1.96	2.17	2.37	2.17	2.07	2.17
159	1.96	2.17	2.37	2.18	2.08	2.17
160	1.96	2.17	2.38	2.18	2.08	2.18
161	1.97	2.17	2.38	2.19	2.09	2.19
162	1.98	2.17	2.39	2.19	2.10	2.19
163	1.98	2.17	2.39	2.20	2.11	2.20
164	1.98	2.17	2.39	2.20	2.11	2.22
165	1.99	2.17	2.39	2.20	2.11	2.22
166	1.99	2.17	2.39	2.21	2.12	2.23
167	1.99	2.19	2.40	2.21	2.13	2.23
168	1.99	2.19	2.41	2.22	2.13	2.23
169	1.99	2.19	2.42	2.22	2.14	2.24
170	2.00	2.19	2.42	2.22	2.14	2.26
171	2.00	2.20	2.43	2.23	2.14	2.26
172	2.00	2.20	2.44	2.23	2.14	2.27
173	2.00	2.22	2.45	2.23	2.14	2.28
174	2.00	2.22	2.45	2.24	2.14	2.28
175	2.01	2.22	2.46	2.24	2.14	2.28
176	2.01	2.22	2.46	2.25	2.14	2.29
177	2.01	2.23	2.46	2.25	2.14	2.29
178	2.02	2.23	2.46	2.26	2.15	2.29
179	2.02	2.23	2.46	2.26	2.16	2.30
180	2.02	2.23	2.46	2.27	2.16	2.30
181	2.02	2.23	2.47	2.27	2.16	2.31
182	2.03	2.23	2.47	2.27	2.16	2.31
183	2.04	2.23	2.48	2.28	2.16	2.33
184	2.04	2.24	2.48	2.28	2.17	2.33
185	2.04	2.24	2.49	2.29	2.17	2.34
186	2.05	2.24	2.49	2.29	2.19	2.34
187	2.07	2.24	2.49	2.29	2.19	2.34
188	2.07	2.24	2.49	2.29	2.20	2.34
189	2.07	2.25	2.50	2.30	2.20	2.36
190	2.08	2.25	2.50	2.30	2.20	2.36
191	2.08	2.25	2.50	2.30	2.21	2.36
192	2.09	2.25	2.50	2.30	2.21	2.36
193	2.10	2.26	2.50	2.30	2.21	2.36
194	2.10	2.26	2.51	2.30	2.21	2.36
195	2.11	2.26	2.52	2.30	2.21	2.37
196	2.11	2.27	2.53	2.31	2.21	2.37
197	2.11	2.27	2.53	2.31	2.21	2.37
198	2.11	2.27	2.53	2.32	2.22	2.37
199	2.11	2.27	2.54	2.32	2.22	2.37
200	2.13	2.28	2.54	2.32	2.22	2.37
201	2.13	2.28	2.55	2.32	2.24	2.37
202	2.13	2.29	2.56	2.32	2.24	2.38
203	2.14	2.29	2.56	2.33	2.24	2.38
204	2.14	2.29	2.56	2.34	2.25	2.38
205	2.14	2.30	2.57	2.34	2.25	2.39
206	2.15	2.30	2.57	2.35	2.26	2.40
207	2.17	2.31	2.58	2.35	2.26	2.41
208	2.17	2.32	2.58	2.36	2.26	2.41
209	2.18	2.33	2.59	2.36	2.27	2.41
210	2.18	2.34	2.60	2.36	2.27	2.42
211	2.18	2.34	2.60	2.37	2.27	2.42
212	2.19	2.34	2.60	2.37	2.27	2.42
213	2.19	2.34	2.61	2.38	2.28	2.43
214	2.19	2.34	2.61	2.38	2.29	2.43
215	2.20	2.35	2.62	2.38	2.29	2.43
216	2.20	2.35	2.62	2.39	2.29	2.44
217	2.20	2.36	2.63	2.40	2.30	2.45
218	2.20	2.36	2.63	2.40	2.30	2.45
219	2.20	2.36	2.63	2.40	2.30	2.45
220	2.21	2.37	2.63	2.40	2.30	2.45
221	2.22	2.37	2.63	2.41	2.31	2.46
222	2.23	2.38	2.65	2.41	2.31	2.46
223	2.23	2.39	2.65	2.42	2.31	2.46
224	2.23	2.39	2.66	2.42	2.31	2.46
225	2.23	2.39	2.66	2.42	2.31	2.46
226	2.23	2.40	2.66	2.46	2.32	2.47
227	2.24	2.40	2.67	2.46	2.32	2.48
228	2.25	2.40	2.67	2.46	2.34	2.48
229	2.25	2.41	2.68	2.46	2.34	2.48
230	2.25	2.41	2.68	2.46	2.34	2.48
231	2.25	2.41	2.69	2.46	2.34	2.50
232	2.26	2.42	2.69	2.47	2.35	2.50
233	2.26	2.42	2.69	2.47	2.35	2.50
234	2.26	2.42	2.70	2.48	2.36	2.50
235	2.27	2.42	2.70	2.48	2.36	2.51
236	2.27	2.42	2.70	2.49	2.37	2.51
237	2.28	2.42	2.70	2.50	2.38	2.51
238	2.28	2.43	2.71	2.50	2.38	2.51
239	2.28	2.43	2.72	2.50	2.38	2.52
240	2.28	2.43	2.72	2.51	2.38	2.52
241	2.28	2.44	2.72	2.51	2.38	2.53
242	2.28	2.44	2.72	2.52	2.38	2.53
243	2.29	2.44	2.72	2.52	2.38	2.54
244	2.29	2.45	2.72	2.53	2.39	2.55
245	2.30	2.45	2.73	2.54	2.40	2.56
246	2.30	2.45	2.73	2.54	2.40	2.56
247	2.31	2.45	2.74	2.54	2.40	2.56
248	2.31	2.45	2.74	2.54	2.41	2.56
249	2.31	2.46	2.75	2.55	2.44	2.56
250	2.32	2.47	2.76	2.55	2.44	2.56
251	2.32	2.47	2.76	2.55	2.44	2.57
252	2.32	2.47	2.77	2.56	2.44	2.57
253	2.32	2.48	2.77	2.56	2.45	2.58
254	2.32	2.48	2.77	2.56	2.45	2.58
255	2.32	2.48	2.77	2.57	2.47	2.58
256	2.32	2.48	2.77	2.57	2.47	2.59
257	2.33	2.49	2.77	2.57	2.47	2.59
258	2.33	2.49	2.77	2.58	2.48	2.59
259	2.33	2.49	2.78	2.58	2.48	2.59
260	2.33	2.50	2.78	2.58	2.49	2.60
261	2.34	2.50	2.78	2.59	2.49	2.60
262	2.34	2.50	2.79	2.59	2.49	2.60
263	2.34	2.50	2.80	2.59	2.49	2.60
264	2.34	2.50	2.80	2.60	2.50	2.60
265	2.35	2.50	2.80	2.61	2.50	2.61

Table A2.3: cont.

266	2.35	2.51	2.80	2.62	2.50	2.61
267	2.35	2.51	2.80	2.62	2.50	2.62
268	2.36	2.52	2.80	2.62	2.51	2.62
269	2.36	2.52	2.82	2.63	2.51	2.63
270	2.36	2.52	2.82	2.63	2.52	2.64
271	2.36	2.52	2.82	2.63	2.52	2.65
272	2.36	2.53	2.82	2.65	2.52	2.65
273	2.36	2.53	2.83	2.65	2.53	2.66
274	2.37	2.53	2.83	2.66	2.53	2.66
275	2.38	2.53	2.83	2.66	2.53	2.67
276	2.38	2.53	2.83	2.66	2.53	2.67
277	2.38	2.54	2.84	2.66	2.54	2.68
278	2.39	2.54	2.85	2.67	2.54	2.69
279	2.39	2.54	2.86	2.67	2.54	2.69
280	2.39	2.54	2.86	2.67	2.54	2.70
281	2.40	2.54	2.87	2.68	2.55	2.70
282	2.41	2.54	2.87	2.68	2.55	2.70
283	2.41	2.55	2.87	2.68	2.55	2.71
284	2.41	2.55	2.87	2.70	2.55	2.71
285	2.42	2.55	2.87	2.70	2.55	2.72
286	2.42	2.55	2.88	2.70	2.55	2.72
287	2.42	2.56	2.88	2.71	2.55	2.72
288	2.42	2.56	2.88	2.71	2.55	2.73
289	2.43	2.56	2.89	2.72	2.56	2.74
290	2.43	2.56	2.89	2.72	2.57	2.74
291	2.43	2.56	2.89	2.72	2.57	2.74
292	2.44	2.56	2.89	2.72	2.58	2.74
293	2.44	2.57	2.89	2.73	2.58	2.74
294	2.45	2.57	2.90	2.73	2.58	2.74
295	2.46	2.57	2.90	2.73	2.58	2.75
296	2.46	2.57	2.90	2.73	2.58	2.75
297	2.46	2.57	2.91	2.74	2.59	2.76
298	2.47	2.58	2.92	2.74	2.59	2.76
299	2.47	2.58	2.92	2.75	2.60	2.76
300	2.47	2.58	2.93	2.75	2.60	2.77
301	2.48	2.58	2.93	2.75	2.60	2.78
302	2.48	2.58	2.93	2.75	2.61	2.78
303	2.49	2.58	2.93	2.76	2.61	2.78
304	2.49	2.58	2.93	2.76	2.61	2.79
305	2.49	2.59	2.94	2.78	2.62	2.80
306	2.49	2.59	2.95	2.78	2.62	2.80
307	2.49	2.59	2.95	2.79	2.62	2.81
308	2.49	2.59	2.95	2.79	2.62	2.82
309	2.50	2.59	2.96	2.79	2.62	2.82
310	2.50	2.59	2.96	2.80	2.62	2.82
311	2.51	2.60	2.96	2.81	2.63	2.83
312	2.51	2.60	2.96	2.83	2.63	2.83
313	2.52	2.61	2.96	2.83	2.64	2.83
314	2.52	2.61	2.97	2.83	2.64	2.83
315	2.52	2.61	2.97	2.83	2.64	2.84
316	2.53	2.61	2.98	2.83	2.65	2.85
317	2.53	2.62	2.98	2.86	2.65	2.85
318	2.53	2.62	2.98	2.86	2.65	2.85
319	2.54	2.63	2.99	2.87	2.66	2.85
320	2.54	2.63	2.99	2.87	2.66	2.86
321	2.54	2.63	2.99	2.87	2.66	2.86
322	2.54	2.63	2.99	2.87	2.66	2.86
323	2.55	2.64	3.00	2.89	2.67	2.86
324	2.55	2.66	3.00	2.89	2.68	2.88
325	2.56	2.66	3.00	2.91	2.68	2.90
326	2.56	2.67	3.00	2.91	2.68	2.90
327	2.56	2.67	3.01	2.91	2.69	2.91
328	2.56	2.67	3.01	2.91	2.69	2.92
329	2.56	2.67	3.01	2.92	2.69	2.92
330	2.56	2.67	3.01	2.93	2.70	2.93
331	2.57	2.68	3.02	2.93	2.70	2.94
332	2.58	2.68	3.02	2.93	2.70	2.94
333	2.58	2.68	3.02	2.94	2.71	2.94
334	2.58	2.69	3.02	2.94	2.71	2.95
335	2.58	2.69	3.02	2.94	2.72	2.96
336	2.59	2.69	3.02	2.95	2.72	2.96
337	2.60	2.70	3.03	2.96	2.72	2.97
338	2.60	2.70	3.03	2.96	2.72	2.97
339	2.60	2.70	3.04	2.97	2.73	2.97
340	2.60	2.70	3.05	2.97	2.74	2.98
341	2.60	2.71	3.05	2.97	2.74	2.98
342	2.61	2.71	3.05	2.97	2.74	2.99
343	2.61	2.71	3.05	2.98	2.74	2.99
344	2.61	2.72	3.05	2.98	2.74	3.00
345	2.62	2.72	3.05	2.98	2.74	3.00
346	2.62	2.72	3.06	2.99	2.75	3.00
347	2.62	2.72	3.06	2.99	2.76	3.01
348	2.63	2.72	3.06	3.00	2.76	3.01
349	2.63	2.73	3.06	3.02	2.77	3.02
350	2.63	2.73	3.06	3.02	2.77	3.02
351	2.64	2.73	3.06	3.02	2.79	3.02
352	2.64	2.73	3.07	3.02	2.80	3.02
353	2.64	2.74	3.08	3.03	2.80	3.02
354	2.65	2.74	3.08	3.03	2.80	3.03
355	2.65	2.74	3.08	3.04	2.81	3.04
356	2.65	2.75	3.09	3.04	2.81	3.04
357	2.65	2.75	3.09	3.05	2.81	3.04
358	2.66	2.75	3.09	3.05	2.81	3.04
359	2.67	2.75	3.09	3.06	2.82	3.05
360	2.67	2.75	3.10	3.06	2.82	3.05
361	2.68	2.76	3.11	3.07	2.83	3.07
362	2.68	2.76	3.12	3.07	2.83	3.07
363	2.70	2.76	3.12	3.08	2.83	3.07
364	2.70	2.76	3.12	3.08	2.83	3.08
365	2.70	2.77	3.12	3.09	2.83	3.08
366	2.72	2.77	3.13	3.09	2.84	3.08
367	2.72	2.77	3.13	3.09	2.85	3.08
368	2.72	2.77	3.13	3.10	2.85	3.08
369	2.73	2.77	3.14	3.10	2.85	3.08
370	2.73	2.78	3.14	3.10	2.86	3.09
371	2.73	2.78	3.14	3.10	2.86	3.09
372	2.74	2.78	3.14	3.11	2.87	3.09
373	2.74	2.79	3.15	3.11	2.87	3.09
374	2.74	2.79	3.15	3.12	2.88	3.10
375	2.74	2.79	3.16	3.12	2.88	3.10
376	2.74	2.80	3.16	3.12	2.88	3.10
377	2.74	2.80	3.17	3.12	2.89	3.10
378	2.74	2.80	3.17	3.13	2.89	3.11
379	2.74	2.80	3.17	3.13	2.89	3.11
380	2.75	2.81	3.17	3.13	2.91	3.12
381	2.75	2.81	3.18	3.13	2.91	3.13
382	2.75	2.81	3.18	3.14	2.91	3.13
383	2.76	2.81	3.18	3.14	2.91	3.13
384	2.77	2.82	3.18	3.14	2.91	3.13
385	2.77	2.82	3.19	3.14	2.92	3.14
386	2.77	2.82	3.19	3.14	2.93	3.14
387	2.78	2.82	3.20	3.14	2.94	3.15
388	2.78	2.83	3.20	3.15	2.94	3.15
389	2.79	2.83	3.22	3.15	2.94	3.15
390	2.80	2.83	3.22	3.16	2.94	3.16
391	2.81	2.83	3.22	3.17	2.94	3.17
392	2.81	2.84	3.22	3.17	2.94	3.17
393	2.82	2.84	3.22	3.17	2.94	3.17
394	2.83	2.84	3.22	3.18	2.95	3.17
395	2.83	2.85	3.22	3.18	2.95	3.18
396	2.83	2.85	3.22	3.19	2.95	3.18
397	2.84	2.85	3.23	3.19	2.96	3.18
398	2.84	2.85	3.23	3.20	2.96	3.19
399	2.84	2.85	3.24	3.20	2.97	3.19
400	2.85	2.86	3.26	3.21	2.97	3.19
401	2.85	2.86	3.26	3.21	2.97	3.20
402	2.86	2.86	3.26	3.22	2.97	3.20
403	2.86	2.86	3.26	3.22	2.98	3.20
404	2.86	2.86	3.27	3.22	2.98	3.20

Table A2.3: cont.

405	2.86	2.87	3.27	3.22	2.98	3.20
406	2.86	2.87	3.27	3.23	2.98	3.20
407	2.87	2.87	3.27	3.24	2.98	3.21
408	2.87	2.87	3.27	3.24	2.98	3.21
409	2.87	2.87	3.27	3.24	2.99	3.21
410	2.87	2.87	3.28	3.24	2.99	3.22
411	2.87	2.87	3.29	3.25	2.99	3.23
412	2.87	2.87	3.29	3.26	2.99	3.23
413	2.88	2.88	3.30	3.26	3.00	3.23
414	2.88	2.88	3.30	3.27	3.00	3.24
415	2.88	2.89	3.32	3.28	3.00	3.25
416	2.88	2.89	3.32	3.28	3.01	3.27
417	2.88	2.89	3.32	3.28	3.02	3.27
418	2.89	2.89	3.32	3.28	3.02	3.27
419	2.89	2.89	3.33	3.30	3.02	3.29
420	2.89	2.89	3.33	3.31	3.03	3.29
421	2.89	2.90	3.33	3.32	3.03	3.30
422	2.90	2.90	3.33	3.33	3.03	3.30
423	2.90	2.90	3.33	3.34	3.04	3.30
424	2.91	2.90	3.34	3.34	3.04	3.31
425	2.91	2.90	3.34	3.34	3.04	3.31
426	2.92	2.90	3.34	3.35	3.05	3.33
427	2.92	2.91	3.35	3.35	3.05	3.33
428	2.92	2.91	3.36	3.37	3.05	3.33
429	2.92	2.91	3.36	3.37	3.06	3.34
430	2.92	2.91	3.36	3.38	3.06	3.35
431	2.93	2.92	3.36	3.38	3.06	3.35
432	2.93	2.92	3.37	3.38	3.07	3.35
433	2.93	2.92	3.38	3.38	3.07	3.35
434	2.93	2.93	3.38	3.39	3.07	3.36
435	2.93	2.93	3.38	3.40	3.07	3.36
436	2.93	2.93	3.38	3.41	3.08	3.37
437	2.94	2.93	3.39	3.42	3.08	3.38
438	2.94	2.94	3.39	3.42	3.08	3.39
439	2.94	2.94	3.39	3.42	3.08	3.39
440	2.94	2.94	3.39	3.42	3.09	3.40
441	2.95	2.94	3.41	3.43	3.10	3.40
442	2.98	2.95	3.41	3.43	3.11	3.43
443	2.98	2.95	3.41	3.43	3.11	3.44
444	2.98	2.95	3.42	3.45	3.11	3.44
445	2.99	2.95	3.42	3.45	3.12	3.44
446	2.99	2.95	3.42	3.45	3.12	3.45
447	2.99	2.96	3.43	3.45	3.13	3.45
448	3.00	2.96	3.43	3.46	3.13	3.45
449	3.00	2.96	3.43	3.46	3.14	3.46
450	3.00	2.97	3.44	3.47	3.15	3.46
451	3.00	2.99	3.44	3.49	3.16	3.47
452	3.01	2.99	3.45	3.50	3.16	3.47
453	3.01	2.99	3.45	3.50	3.16	3.47
454	3.01	2.99	3.45	3.50	3.16	3.48
455	3.01	2.99	3.45	3.51	3.17	3.49
456	3.01	2.99	3.45	3.52	3.18	3.49
457	3.03	3.00	3.45	3.52	3.19	3.49
458	3.03	3.00	3.45	3.53	3.19	3.49
459	3.03	3.00	3.45	3.53	3.19	3.49
460	3.04	3.00	3.45	3.54	3.20	3.50
461	3.04	3.00	3.46	3.54	3.21	3.50
462	3.05	3.01	3.46	3.54	3.21	3.50
463	3.05	3.01	3.46	3.55	3.22	3.50
464	3.05	3.01	3.47	3.56	3.22	3.51
465	3.05	3.01	3.47	3.56	3.22	3.51
466	3.05	3.01	3.47	3.56	3.23	3.51
467	3.06	3.02	3.47	3.56	3.23	3.52
468	3.06	3.02	3.47	3.57	3.24	3.53
469	3.07	3.02	3.48	3.57	3.24	3.53
470	3.08	3.02	3.48	3.58	3.25	3.54
471	3.08	3.02	3.49	3.59	3.26	3.54
472	3.08	3.03	3.49	3.59	3.26	3.55
473	3.08	3.03	3.50	3.59	3.26	3.55
474	3.08	3.03	3.50	3.59	3.26	3.55
475	3.09	3.04	3.50	3.59	3.26	3.55
476	3.09	3.04	3.50	3.60	3.27	3.55
477	3.11	3.04	3.51	3.60	3.27	3.56
478	3.11	3.05	3.51	3.60	3.27	3.56
479	3.11	3.05	3.51	3.60	3.28	3.56
480	3.12	3.05	3.52	3.60	3.28	3.56
481	3.12	3.05	3.52	3.61	3.28	3.58
482	3.13	3.06	3.53	3.61	3.28	3.58
483	3.13	3.07	3.54	3.61	3.28	3.58
484	3.13	3.07	3.54	3.62	3.29	3.59
485	3.13	3.08	3.54	3.62	3.29	3.59
486	3.14	3.08	3.54	3.65	3.29	3.59
487	3.14	3.08	3.56	3.65	3.30	3.61
488	3.15	3.08	3.56	3.65	3.30	3.61
489	3.15	3.08	3.56	3.66	3.31	3.61
490	3.15	3.08	3.56	3.66	3.32	3.61
491	3.15	3.08	3.57	3.67	3.32	3.62
492	3.15	3.08	3.57	3.67	3.33	3.63
493	3.15	3.08	3.57	3.68	3.33	3.63
494	3.15	3.09	3.57	3.69	3.33	3.63
495	3.15	3.09	3.58	3.69	3.34	3.63
496	3.16	3.09	3.58	3.69	3.34	3.66
497	3.16	3.10	3.58	3.70	3.35	3.67
498	3.16	3.10	3.58	3.70	3.36	3.67
499	3.17	3.10	3.58	3.71	3.37	3.67
500	3.18	3.11	3.58	3.71	3.37	3.68
501	3.19	3.11	3.58	3.71	3.37	3.69
502	3.19	3.11	3.58	3.71	3.37	3.69
503	3.19	3.12	3.58	3.72	3.37	3.69
504	3.19	3.12	3.59	3.73	3.38	3.70
505	3.20	3.12	3.59	3.75	3.38	3.70
506	3.20	3.12	3.59	3.75	3.38	3.71
507	3.20	3.12	3.60	3.77	3.38	3.71
508	3.21	3.12	3.60	3.78	3.39	3.71
509	3.21	3.12	3.60	3.78	3.41	3.74
510	3.21	3.13	3.60	3.78	3.41	3.74
511	3.21	3.13	3.60	3.78	3.42	3.75
512	3.23	3.13	3.61	3.79	3.42	3.75
513	3.24	3.13	3.61	3.79	3.42	3.75
514	3.25	3.13	3.62	3.79	3.44	3.75
515	3.25	3.13	3.62	3.80	3.44	3.76
516	3.26	3.14	3.63	3.80	3.45	3.76
517	3.26	3.15	3.63	3.80	3.45	3.76
518	3.27	3.16	3.63	3.81	3.46	3.77
519	3.27	3.16	3.63	3.82	3.46	3.77
520	3.27	3.16	3.63	3.82	3.47	3.77
521	3.28	3.16	3.63	3.82	3.47	3.77
522	3.28	3.16	3.64	3.82	3.47	3.78
523	3.28	3.16	3.64	3.83	3.47	3.79
524	3.28	3.17	3.65	3.84	3.49	3.80
525	3.29	3.17	3.65	3.85	3.50	3.81
526	3.29	3.17	3.65	3.86	3.50	3.82
527	3.29	3.18	3.65	3.86	3.50	3.82
528	3.30	3.18	3.66	3.86	3.50	3.83
529	3.30	3.18	3.66	3.87	3.51	3.84
530	3.31	3.18	3.67	3.87	3.51	3.85
531	3.31	3.18	3.67	3.87	3.52	3.85
532	3.31	3.18	3.67	3.88	3.53	3.87
533	3.32	3.19	3.68	3.88	3.53	3.89
534	3.32	3.19	3.68	3.89	3.53	3.89
535	3.32	3.20	3.69	3.90	3.53	3.90
536	3.33	3.20	3.69	3.90	3.53	3.91
537	3.34	3.20	3.70	3.90	3.53	3.91
538	3.34	3.20	3.70	3.90	3.54	3.92
539	3.34	3.21	3.70	3.91	3.54	3.92
540	3.34	3.21	3.71	3.92	3.54	3.93
541	3.35	3.21	3.71	3.93	3.55	3.93
542	3.35	3.22	3.71	3.94	3.55	3.94
543	3.36	3.22	3.72	3.95	3.55	3.95

Table A2.3: cont.

544	3.36	3.22	3.72	3.97	3.55	3.95
545	3.36	3.22	3.73	3.97	3.56	3.96
546	3.37	3.22	3.73	3.97	3.56	3.96
547	3.37	3.22	3.73	3.97	3.56	3.96
548	3.37	3.22	3.73	3.99	3.57	3.96
549	3.38	3.23	3.73	3.99	3.58	3.97
550	3.38	3.23	3.75	3.99	3.58	3.98
551	3.38	3.24	3.76	4.00	3.58	3.99
552	3.38	3.24	3.76	4.01	3.59	3.99
553	3.39	3.24	3.76	4.02	3.59	4.00
554	3.39	3.25	3.76	4.03	3.59	4.00
555	3.39	3.25	3.76	4.03	3.60	4.01
556	3.39	3.25	3.77	4.04	3.60	4.02
557	3.40	3.25	3.77	4.04	3.61	4.02
558	3.40	3.25	3.77	4.04	3.61	4.03
559	3.41	3.26	3.77	4.05	3.61	4.03
560	3.41	3.26	3.78	4.05	3.61	4.04
561	3.41	3.26	3.79	4.05	3.62	4.04
562	3.42	3.26	3.79	4.05	3.63	4.04
563	3.42	3.27	3.80	4.06	3.63	4.04
564	3.42	3.27	3.80	4.06	3.64	4.05
565	3.44	3.27	3.81	4.07	3.64	4.06
566	3.44	3.28	3.81	4.07	3.65	4.07
567	3.45	3.28	3.81	4.08	3.65	4.08
568	3.45	3.28	3.81	4.08	3.65	4.08
569	3.46	3.28	3.82	4.08	3.65	4.09
570	3.46	3.29	3.82	4.10	3.66	4.09
571	3.46	3.29	3.82	4.10	3.66	4.09
572	3.46	3.30	3.82	4.10	3.66	4.11
573	3.47	3.30	3.83	4.10	3.66	4.11
574	3.47	3.30	3.83	4.10	3.66	4.13
575	3.47	3.31	3.84	4.11	3.66	4.14
576	3.47	3.31	3.84	4.12	3.66	4.16
577	3.47	3.31	3.84	4.12	3.67	4.17
578	3.48	3.31	3.85	4.13	3.67	4.17
579	3.48	3.31	3.85	4.13	3.67	4.18
580	3.48	3.31	3.85	4.14	3.68	4.19
581	3.49	3.31	3.86	4.15	3.68	4.19
582	3.49	3.31	3.86	4.15	3.68	4.19
583	3.50	3.32	3.86	4.15	3.68	4.20
584	3.50	3.32	3.86	4.15	3.68	4.20
585	3.50	3.33	3.86	4.15	3.69	4.21
586	3.51	3.33	3.86	4.16	3.70	4.22
587	3.51	3.33	3.87	4.16	3.70	4.24
588	3.51	3.34	3.88	4.17	3.70	4.25
589	3.51	3.34	3.88	4.17	3.71	4.25
590	3.52	3.36	3.89	4.18	3.71	4.26
591	3.54	3.36	3.89	4.19	3.71	4.26
592	3.54	3.36	3.89	4.20	3.72	4.27
593	3.55	3.36	3.90	4.22	3.73	4.27
594	3.55	3.37	3.90	4.22	3.74	4.28
595	3.55	3.37	3.92	4.24	3.75	4.29
596	3.56	3.37	3.92	4.24	3.75	4.30
597	3.56	3.37	3.95	4.25	3.76	4.33
598	3.56	3.37	3.95	4.25	3.77	4.33
599	3.57	3.38	3.95	4.26	3.77	4.33
600	3.58	3.38	3.95	4.27	3.78	4.34
601	3.58	3.39	3.97	4.27	3.78	4.35
602	3.58	3.39	3.97	4.28	3.79	4.36
603	3.58	3.39	3.98	4.29	3.79	4.36
604	3.59	3.40	3.99	4.31	3.79	4.37
605	3.59	3.40	3.99	4.35	3.80	4.37
606	3.59	3.40	3.99	4.35	3.80	4.37
607	3.59	3.40	3.99	4.37	3.81	4.41
608	3.59	3.40	4.01	4.38	3.82	4.41
609	3.60	3.41	4.02	4.42	3.82	4.43
610	3.60	3.41	4.02	4.42	3.82	4.43
611	3.60	3.41	4.02	4.43	3.82	4.44
612	3.61	3.41	4.03	4.44	3.83	4.45
613	3.63	3.41	4.04	4.45	3.83	4.45
614	3.63	3.42	4.04	4.46	3.85	4.45
615	3.64	3.43	4.05	4.46	3.88	4.46
616	3.64	3.43	4.05	4.47	3.89	4.46
617	3.64	3.44	4.05	4.47	3.89	4.48
618	3.64	3.44	4.05	4.47	3.89	4.49
619	3.65	3.44	4.05	4.48	3.90	4.50
620	3.65	3.44	4.07	4.50	3.91	4.51
621	3.66	3.44	4.07	4.50	3.91	4.51
622	3.67	3.44	4.07	4.51	3.92	4.51
623	3.68	3.45	4.08	4.52	3.92	4.52
624	3.68	3.45	4.08	4.53	3.92	4.53
625	3.68	3.46	4.09	4.55	3.93	4.53
626	3.68	3.46	4.09	4.56	3.93	4.53
627	3.68	3.46	4.09	4.56	3.94	4.55
628	3.69	3.46	4.10	4.56	3.94	4.55
629	3.70	3.47	4.10	4.57	3.95	4.56
630	3.70	3.47	4.13	4.59	3.95	4.56
631	3.71	3.48	4.13	4.59	3.95	4.56
632	3.71	3.48	4.13	4.60	3.95	4.57
633	3.72	3.50	4.13	4.60	3.96	4.57
634	3.74	3.50	4.13	4.61	3.97	4.57
635	3.74	3.50	4.14	4.63	3.97	4.59
636	3.75	3.51	4.15	4.64	3.99	4.59
637	3.75	3.51	4.15	4.65	4.00	4.60
638	3.75	3.52	4.15	4.68	4.00	4.60
639	3.75	3.52	4.16	4.69	4.00	4.62
640	3.75	3.53	4.16	4.73	4.01	4.62
641	3.76	3.53	4.16	4.74	4.01	4.64
642	3.76	3.53	4.17	4.74	4.01	4.64
643	3.76	3.53	4.17	4.74	4.02	4.66
644	3.76	3.53	4.18	4.74	4.02	4.66
645	3.77	3.53	4.18	4.75	4.02	4.66
646	3.77	3.54	4.19	4.75	4.02	4.66
647	3.77	3.54	4.19	4.76	4.02	4.67
648	3.78	3.55	4.19	4.77	4.03	4.68
649	3.79	3.55	4.19	4.77	4.05	4.68
650	3.79	3.55	4.20	4.79	4.07	4.71
651	3.80	3.55	4.20	4.79	4.08	4.72
652	3.80	3.55	4.20	4.80	4.09	4.72
653	3.80	3.56	4.21	4.81	4.09	4.72
654	3.81	3.56	4.21	4.82	4.09	4.73
655	3.81	3.56	4.21	4.82	4.10	4.73
656	3.81	3.57	4.21	4.83	4.12	4.74
657	3.81	3.57	4.22	4.83	4.12	4.74
658	3.82	3.58	4.22	4.83	4.12	4.75
659	3.82	3.58	4.22	4.84	4.13	4.76
660	3.82	3.58	4.23	4.85	4.14	4.77
661	3.83	3.58	4.23	4.86	4.14	4.77
662	3.83	3.58	4.23	4.87	4.14	4.77
663	3.83	3.59	4.23	4.87	4.14	4.81
664	3.83	3.59	4.24	4.88	4.14	4.82
665	3.84	3.59	4.24	4.90	4.15	4.82
666	3.84	3.60	4.24	4.92	4.16	4.82
667	3.84	3.61	4.24	4.92	4.17	4.83
668	3.85	3.61	4.24	4.93	4.17	4.84
669	3.85	3.61	4.25	4.94	4.17	4.84
670	3.85	3.61	4.25	4.96	4.18	4.86
671	3.86	3.61	4.25	4.96	4.18	4.87
672	3.86	3.62	4.25	4.96	4.20	4.88
673	3.86	3.62	4.26	4.97	4.20	4.90
674	3.87	3.63	4.27	4.98	4.20	4.91
675	3.88	3.63	4.29	5.00	4.20	4.91
676	3.89	3.63	4.29	5.01	4.20	4.92
677	3.90	3.63	4.29	5.01	4.22	4.92
678	3.91	3.63	4.30	5.02	4.22	4.93
679	3.91	3.63	4.30	5.02	4.23	4.93
680	3.92	3.64	4.30	5.03	4.25	4.94
681	3.93	3.64	4.31	5.04	4.26	4.94
682	3.93	3.64	4.31	5.07	4.28	4.95

Table A2.3: cont.

683	3.93	3.64	4.32	5.08	4.29	4.97
684	3.93	3.65	4.33	5.08	4.29	4.98
685	3.94	3.65	4.33	5.13	4.30	4.98
686	3.95	3.66	4.35	5.13	4.30	5.00
687	3.95	3.66	4.35	5.14	4.30	5.01
688	3.97	3.66	4.35	5.25	4.30	5.03
689	3.98	3.66	4.38	5.26	4.31	5.04
690	3.99	3.67	4.39	5.30	4.32	5.05
691	3.99	3.67	4.39	5.30	4.32	5.07
692	4.00	3.67	4.39	5.32	4.32	5.08
693	4.00	3.67	4.40	5.34	4.33	5.09
694	4.01	3.67	4.41	5.35	4.34	5.10
695	4.01	3.67	4.41	5.36	4.35	5.14
696	4.01	3.67	4.41	5.37	4.36	5.14
697	4.02	3.67	4.44	5.38	4.37	5.16
698	4.02	3.68	4.45	5.39	4.37	5.16
699	4.03	3.68	4.45	5.40	4.38	5.17
700	4.03	3.68	4.45	5.45	4.39	5.18
701	4.04	3.68	4.45	5.50	4.40	5.18
702	4.04	3.68	4.46	5.54	4.42	5.20
703	4.06	3.69	4.47	5.57	4.43	5.21
704	4.06	3.69	4.47	5.58	4.44	5.23
705	4.07	3.69	4.48	5.62	4.44	5.23
706	4.07	3.69	4.49	5.68	4.44	5.24
707	4.07	3.69	4.49	5.69	4.46	5.25
708	4.08	3.70	4.49	5.70	4.47	5.26
709	4.08	3.70	4.49	5.72	4.47	5.28
710	4.08	3.71	4.50	5.74	4.48	5.28
711	4.09	3.72	4.51	5.74	4.49	5.29
712	4.09	3.72	4.51	5.74	4.50	5.29
713	4.09	3.72	4.51	5.75	4.51	5.29
714	4.11	3.72	4.51	5.75	4.51	5.30
715	4.12	3.73	4.52	5.75	4.51	5.30
716	4.13	3.74	4.52	5.79	4.51	5.30
717	4.13	3.74	4.52	5.89	4.51	5.31
718	4.14	3.74	4.53	5.93	4.52	5.32
719	4.14	3.75	4.55	5.94	4.52	5.33
720	4.15	3.76	4.55	5.94	4.52	5.34
721	4.15	3.76	4.56	5.96	4.53	5.35
722	4.15	3.76	4.57	5.96	4.55	5.37
723	4.15	3.76	4.57	5.97	4.55	5.37
724	4.16	3.76	4.58	5.97	4.57	5.37
725	4.16	3.76	4.59	5.98	4.57	5.38
726	4.18	3.76	4.59	6.04	4.58	5.38
727	4.18	3.77	4.59	6.11	4.58	5.38
728	4.19	3.78	4.59	6.12	4.59	5.39
729	4.21	3.78	4.60	6.13	4.60	5.41
730	4.22	3.79	4.60	6.13	4.61	5.42
731	4.22	3.79	4.61	6.15	4.61	5.43
732	4.22	3.79	4.61	6.15	4.62	5.43
733	4.23	3.79	4.62	6.15	4.64	5.44
734	4.23	3.79	4.62	6.17	4.64	5.44
735	4.23	3.79	4.62	6.26	4.66	5.45
736	4.24	3.80	4.62	6.27	4.67	5.46
737	4.25	3.80	4.62	6.28	4.68	5.47
738	4.25	3.80	4.62	6.29	4.68	5.48
739	4.25	3.80	4.63	6.30	4.69	5.48
740	4.27	3.80	4.64	6.31	4.69	5.51
741	4.30	3.81	4.65	6.31	4.70	5.51
742	4.30	3.82	4.66	6.34	4.70	5.51
743	4.30	3.82	4.68	6.37	4.71	5.58
744	4.31	3.83	4.68	6.38	4.71	5.61
745	4.31	3.83	4.68	6.38	4.72	5.61
746	4.31	3.83	4.69	6.46	4.73	5.63
747	4.32	3.83	4.70	6.50	4.73	5.63
748	4.32	3.83	4.72	6.62	4.73	5.67
749	4.33	3.83	4.72	6.64	4.76	5.70
750	4.35	3.84	4.72	6.67	4.77	5.71
751	4.36	3.84	4.72	6.71	4.77	5.72
752	4.36	3.84	4.74	6.72	4.79	5.74
753	4.37	3.85	4.74	6.74	4.79	5.75
754	4.37	3.85	4.75	6.92	4.81	5.76
755	4.39	3.85	4.75	6.93	4.81	5.77
756	4.40	3.86	4.76	6.94	4.82	5.78
757	4.41	3.86	4.76	6.97	4.82	5.80
758	4.42	3.86	4.77	6.98	4.82	5.81
759	4.42	3.87	4.77	7.19	4.83	5.81
760	4.44	3.87	4.77	7.38	4.84	5.83
761	4.45	3.87	4.78	7.88	4.85	5.87
762	4.49	3.88	4.79	7.94	4.86	5.87
763	4.49	3.88	4.79	8.08	4.86	5.88
764	4.53	3.88	4.80	8.23	4.90	5.88
765	4.53	3.88	4.81	8.33	4.90	5.89
766	4.54	3.88	4.82	9.25	4.92	5.91
767	4.54	3.89	4.82	9.43	4.93	5.97
768	4.56	3.90	4.83	10.23	4.94	5.98
769	4.57	3.90	4.84	10.36	4.95	5.99
770	4.57	3.90	4.85	10.43	4.95	6.00
771	4.58	3.90	4.87	11.68	4.96	6.04
772	4.59	3.90	4.87	11.69	4.96	6.07
773	4.61	3.91	4.89	12.30	4.96	6.09
774	4.64	3.92	4.89	12.94	4.96	6.12
775	4.64	3.93	4.89	13.12	4.97	6.16
776	4.65	3.93	4.89	13.63	4.98	6.17
777	4.65	3.93	4.89	15.35	4.98	6.21
778	4.67	3.93	4.89	19.06	4.99	6.25
779	4.67	3.94	4.90	38.37	5.00	6.28
780	4.68	3.94	4.91	42.94	5.01	6.34
781	4.68	3.94	4.91	56.81	5.01	6.34
782	4.70	3.94	4.91		5.03	6.35
783	4.70	3.94	4.92		5.05	6.40
784	4.70	3.94	4.94		5.05	6.40
785	4.70	3.95	4.94		5.06	6.43
786	4.71	3.95	4.95		5.08	6.46
787	4.72	3.95	4.95		5.12	6.48
788	4.72	3.96	4.95		5.12	6.49
789	4.73	3.96	4.95		5.13	6.54
790	4.73	3.97	4.95		5.13	6.55
791	4.75	3.97	4.96		5.14	6.57
792	4.75	3.97	4.96		5.15	6.59
793	4.75	3.97	4.97		5.16	6.65
794	4.77	3.98	4.98		5.17	6.68
795	4.78	3.98	4.98		5.18	6.68
796	4.78	3.98	4.98		5.19	6.71
797	4.78	3.98	4.99		5.19	6.79
798	4.81	3.99	5.00		5.20	6.80
799	4.82	4.00	5.02		5.21	6.92
800	4.82	4.00	5.04		5.21	6.96
801	4.87	4.00	5.04		5.22	6.99
802	4.90	4.00	5.06		5.22	7.07
803	4.91	4.00	5.06		5.22	7.08
804	4.92	4.00	5.07		5.22	7.08
805	4.93	4.01	5.08		5.23	7.09
806	4.94	4.01	5.09		5.23	7.09
807	4.95	4.03	5.09		5.23	7.18
808	5.02	4.03	5.09		5.25	7.22
809	5.03	4.03	5.09		5.27	7.29
810	5.03	4.04	5.10		5.28	7.30
811	5.13	4.04	5.12		5.35	7.34
812	5.13	4.04	5.13		5.36	7.46
813	5.14	4.05	5.15		5.37	7.47
814	5.14	4.05	5.15		5.37	7.48
815	5.17	4.05	5.18		5.40	7.49
816	5.21	4.06	5.19		5.42	7.49
817	5.25	4.06	5.19		5.43	7.51
818	5.26	4.06	5.20		5.46	7.54
819	5.26	4.06	5.20		5.47	7.65
820	5.27	4.07	5.22		5.48	7.69
821	5.27	4.07	5.22		5.49	7.80

Table A2.3: cont.

822	5.27	4.07	5.23		5.49	7.80
823	5.30	4.07	5.23		5.51	7.89
824	5.34	4.07	5.24		5.52	7.92
825	5.41	4.08	5.24		5.55	7.92
826	5.43	4.09	5.25		5.57	7.97
827	5.46	4.09	5.25		5.59	8.06
828	5.47	4.12	5.26		5.59	8.10
829	5.48	4.12	5.27		5.62	8.11
830	5.50	4.12	5.27		5.65	8.18
831	5.51	4.13	5.27		5.66	8.28
832	5.53	4.13	5.28		5.68	8.52
833	5.56	4.13	5.29		5.70	8.65
834	5.59	4.15	5.29		5.73	8.68
835	5.60	4.17	5.30		5.77	8.78
836	5.63	4.18	5.30		5.78	8.83
837	5.64	4.18	5.30		5.78	8.85
838	5.68	4.19	5.31		5.80	9.14
839	5.70	4.19	5.31		5.80	9.33
840	5.70	4.20	5.32		5.85	9.40
841	5.75	4.20	5.34		5.86	9.46
842	5.81	4.21	5.36		5.89	9.77
843	5.82	4.21	5.37		5.90	9.89
844	5.83	4.21	5.38		5.93	9.93
845	5.83	4.21	5.38		5.97	10.47
846	5.93	4.22	5.39		5.98	10.52
847	6.07	4.23	5.39		6.00	10.64
848	6.08	4.23	5.39		6.02	11.36
849	6.09	4.24	5.40		6.02	12.45
850	6.09	4.25	5.41		6.02	12.50
851	6.09	4.26	5.42		6.04	13.64
852	6.16	4.27	5.42		6.05	13.74
853	6.20	4.27	5.42		6.06	14.05
854	6.21	4.27	5.47		6.08	14.83
855	6.27	4.27	5.48		6.11	21.19
856	6.29	4.27	5.50		6.11	45.09
857	6.37	4.28	5.51		6.13	53.70
858	6.38	4.28	5.51		6.15	60.33
859	6.42	4.28	5.51		6.16	68.33
860	6.50	4.29	5.52		6.16	71.36
861	6.50	4.30	5.54		6.17	75.71
862	6.55	4.30	5.56		6.19	
863	6.56	4.31	5.56		6.21	
864	6.73	4.31	5.60		6.23	
865	6.86	4.31	5.60		6.26	
866	6.90	4.32	5.60		6.27	
867	6.95	4.33	5.61		6.28	
868	6.96	4.33	5.61		6.30	
869	6.96	4.33	5.63		6.36	
870	7.02	4.33	5.65		6.37	
871	7.09	4.33	5.65		6.40	
872	7.13	4.33	5.69		6.44	
873	7.34	4.33	5.71		6.44	
874	7.60	4.34	5.73		6.49	
875	7.61	4.35	5.78		6.49	
876	7.64	4.35	5.81		6.59	
877	7.68	4.36	5.81		6.65	
878	7.81	4.36	5.85		6.66	
879	7.89	4.37	5.85		6.67	
880	8.05	4.38	5.87		6.71	
881	8.37	4.39	5.91		6.86	
882	8.55	4.40	5.91		6.91	
883	8.95	4.40	5.92		6.92	
884	9.04	4.41	5.94		6.96	
885	9.26	4.42	5.95		6.99	
886	9.90	4.42	5.97		7.05	
887	10.13	4.42	5.97		7.05	
888	11.05	4.42	5.97		7.05	
889	14.87	4.43	6.02		7.06	
890	18.39	4.44	6.02		7.07	
891	27.76	4.45	6.06		7.07	
892	29.43	4.46	6.11		7.08	
893	29.43	4.46	6.12		7.08	
894	29.98	4.46	6.14		7.08	
895	30.22	4.47	6.16		7.10	
896	30.52	4.47	6.24		7.14	
897	36.47	4.47	6.27		7.36	
898	42.67	4.47	6.29		7.43	
899	43.04	4.48	6.30		7.50	
900		4.48	6.30		7.55	
901		4.48	6.31		7.55	
902		4.49	6.32		7.60	
903		4.49	6.35		7.77	
904		4.50	6.37		7.79	
905		4.51	6.39		7.97	
906		4.52	6.39		7.97	
907		4.53	6.39		8.26	
908		4.54	6.40		8.31	
909		4.54	6.41		8.57	
910		4.54	6.41		8.63	
911		4.55	6.42		8.68	
912		4.56	6.43		8.71	
913		4.56	6.43		8.80	
914		4.57	6.46		9.34	
915		4.58	6.49		9.50	
916		4.58	6.49		9.74	
917		4.58	6.55		9.80	
918		4.59	6.56		9.89	
919		4.59	6.57		10.15	
920		4.60	6.58		10.74	
921		4.60	6.60		10.75	
922		4.60	6.66		10.98	
923		4.62	6.66		12.11	
924		4.63	6.67		12.12	
925		4.63	6.73		12.63	
926		4.64	6.75		14.05	
927		4.64	6.85		14.38	
928		4.65	6.89		14.68	
929		4.65	6.98		19.85	
930		4.67	6.98		19.87	
931		4.68	7.00		53.31	
932		4.68	7.01		55.96	
933		4.69	7.04		62.09	
934		4.70	7.05		76.51	
935		4.70	7.15			
936		4.70	7.19			
937		4.71	7.31			
938		4.71	7.32			
939		4.71	7.35			
940		4.72	7.45			
941		4.73	7.46			
942		4.74	7.62			
943		4.74	7.76			
944		4.76	7.84			
945		4.77	7.98			
946		4.78	8.15			
947		4.81	8.16			
948		4.82	8.18			
949		4.82	8.21			
950		4.82	8.29			
951		4.82	8.40			
952		4.83	8.43			
953		4.83	8.60			
954		4.83	8.67			
955		4.85	8.76			
956		4.85	9.15			
957		4.86	9.18			
958		4.86	9.34			
959		4.87	9.34			
960		4.89	9.50			

Table A2.3: cont.

961		4.90	9.50			
962		4.91	9.60			
963		4.94	9.69			
964		4.96	9.82			
965		4.97	10.42			
966		4.98	10.50			
967		4.99	12.68			
968		5.02	13.66			
969		5.04	15.52			
970		5.06	16.34			
971		5.07	16.50			
972		5.07	21.88			
973		5.08	26.43			
974		5.09	26.78			
975		5.10	27.90			
976		5.16	29.35			
977		5.18	30.81			
978		5.19	33.67			
979		5.22	35.55			
980		5.25	35.98			
981		5.27	40.06			
982		5.28	40.59			
983		5.29	41.41			
984		5.31	43.82			
985		5.31	44.19			
986		5.32	48.30			
987		5.33	49.42			
988		5.33	53.25			
989		5.33				
990		5.34				
991		5.35				
992		5.35				
993		5.36				
994		5.37				
995		5.38				
996		5.40				
997		5.41				
998		5.41				
999		5.41				
1000		5.42				
1001		5.44				
1002		5.44				
1003		5.44				
1004		5.45				
1005		5.46				
1006		5.48				
1007		5.49				
1008		5.51				
1009		5.52				
1010		5.52				
1011		5.53				
1012		5.54				
1013		5.55				
1014		5.55				
1015		5.59				
1016		5.59				
1017		5.61				
1018		5.62				
1019		5.62				
1020		5.63				
1021		5.64				
1022		5.65				
1023		5.67				
1024		5.67				
1025		5.69				
1026		5.70				
1027		5.73				
1028		5.73				
1029		5.79				
1030		5.81				
1031		5.81				
1032		5.81				
1033		5.81				
1034		5.83				
1035		5.83				
1036		5.83				
1037		5.91				
1038		6.03				
1039		6.05				
1040		6.07				
1041		6.10				
1042		6.10				
1043		6.11				
1044		6.15				
1045		6.15				
1046		6.16				
1047		6.16				
1048		6.25				
1049		6.26				
1050		6.28				
1051		6.33				
1052		6.36				
1053		6.39				
1054		6.43				
1055		6.46				
1056		6.47				
1057		6.49				
1058		6.56				
1059		6.56				
1060		6.56				
1061		6.58				
1062		6.65				
1063		6.68				
1064		6.73				
1065		6.78				
1066		6.80				
1067		6.83				
1068		7.02				
1069		7.02				
1070		7.02				
1071		7.03				
1072		7.05				
1073		7.13				
1074		7.24				
1075		7.36				
1076		7.39				
1077		7.40				
1078		7.41				
1079		7.41				
1080		7.43				
1081		7.45				
1082		7.65				
1083		8.26				
1084		8.26				
1085		8.27				
1086		8.42				
1087		8.80				
1088		8.82				
1089		8.93				
1090		9.13				
1091		9.22				
1092		9.22				
1093		10.52				
1094		10.64				
1095		11.93				
1096		13.00				
1097		13.92				
1098		14.15				
1099		15.72				

Table A2.3: cont.

1100		18.75				
1101		22.46				
1102		27.26				
1103		29.66				
1104		32.30				
1105		33.14				
1106		33.64				
1107		38.17				
1108		40.14				
1109		40.14				
1110		40.29				
1111		49.81				

Appendix A3 - Equivalent Bubble Size Measurements for the Air/Water/1% Copy Paper System

This appendix tabulates the equivalent bubble diameter measurements recorded for the air/water/1% copy paper system flowing through the cocurrent bubble column. Table A3.1 summarizes the equivalent bubble diameter number density for all bubble diameters. Table A3.2 tabulates the equivalent bubble diameter number density for all data with $d \leq 12$ mm. Table A3.3 presents all of the equivalent bubble diameter measurements obtained from the FXR images.

Table A3.1: Summary of the equivalent bubble diameter number density for all the air/water/l% copy paper data obtained in this study.

Copy Paper Consistency (%)	1	1	1	1	1	1
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
0 < d ≤ 1	0.0	0.0	0.0	0.0	0.0	0.0
1 < d ≤ 1.5	4.1	1.4	0.6	0.8	2.2	4.2
1.5 < d ≤ 2	13.5	7.9	5.5	9.3	9.0	13.5
2 < d ≤ 2.5	21.3	13.2	11.6	20.9	13.5	21.2
2.5 < d ≤ 3	20.2	20.6	22.3	20.0	15.1	15.1
3 < d ≤ 3.5	15.4	20.0	17.7	11.3	14.1	10.3
3.5 < d ≤ 4	6.0	13.8	12.1	9.7	10.8	9.9
4 < d ≤ 4.5	7.5	8.2	10.2	6.5	9.0	7.3
4.5 < d ≤ 5	4.5	4.5	5.5	6.5	6.1	4.8
5 < d ≤ 5.5	1.5	2.9	3.0	4.9	3.7	1.8
5.5 < d ≤ 6	1.1	1.6	2.5	2.4	4.9	2.0
6 < d ≤ 6.5	0.4	0.9	1.6	1.6	2.9	1.2
6.5 < d ≤ 7	0.4	0.5	1.9	0.6	1.6	1.2
7 < d ≤ 7.5	0.0	0.5	0.8	1.2	1.2	0.8
7.5 < d ≤ 8	04 .	0.5	0.9	04 .	10 .	02 .
8 < d ≤ 8.5	00 .	0.5	0.2	02 .	04 .	12 .
8.5 < d ≤ 9	00 .	0.0	0.2	02 .	04 .	10 .
9 < d ≤ 9.5	00 .	0.5	0.2	04 .	06 .	00 .
9.5 < d ≤ 10	00 .	[illegible]	0.2	04 .	04 .	08 .
10 < d ≤ 10.5	00 .	0.2	0.2	02 .	02 .	06 .
10.5 < d ≤ 11	00 .	0.0	0.2	0 0	02 .	02 .
11 < d ≤ 11.5	04 .	0.0	0.0	0’0 .	00 .	00 .
11.5 < d ≤ 12	00 .	0.0	0.3	00 .	04 .	04 .
d > 12	34 .	2.5	2.5	24 .	24 .	22 .

Table A3.2: Summary of the equivalent bubble diameter number density for the d ≤ 12 mm air/water/1% copy paper data obtained in this study.

Copy Paper Consistency (%)	1	1	1	1	1	1
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
0 < d ≤ 1	0.0	0.0	0.0	0.0	0.0	0.0
1 < d ≤ 1.5	4.3	1.4	0.6	0.8	2.2	4.3
1.5 < d ≤ 2	14.0	8.1	5.6	9.5	9.2	13.8
2 < d ≤ 2.5	22.1	13.5	11.9	21.4	13.9	21.6
2.5 < d ≤ 3	20.9	21.2	22.9	20.5	15.5	15.5
3 < d ≤ 3.5	15.9	20.5	18.2	11.6	14.5	10.5
3.5 < d ≤ 4	6.2	14.2	12.4	10.0	11.0	10.1
4 < d ≤ 4.5	7.8	8.4	10.5	6.6	9.2	7.4
4.5 < d ≤ 5	4.7	4.7	5.6	6.6	6.2	4.9
5 < d ≤ 5.5	1.6	3.0	3.1	5.0	3.8	1.9
5.5 < d ≤ 6	1.2	1.6	2.6	2.5	5.0	2.1
6 < d ≤ 6.5	0.4	0.9	1.6	1.7	3.0	1.2
6.5 < d ≤ 7	0.4	0.5	1.9	0.6	1.6	1.2
7 < d ≤ 7.5	0.0	0.5	0.8	1.2	1.2	0.8
7.5 < d ≤ 8	0.4	0.5	1.0	0.4	1.0	0.2
8 < d ≤ 8.5	0.0	0.5	0.2	0.2	0.4	1.2
8.5 < d ≤ 9	0.0	0.0	0.2	0.2	0.4	1.0
9 < d ≤ 9.5	0.0	0.5	0.2	0.4	0.6	0.0
9.5 < d ≤ 10	0.0	0.0	0.2	0.4	0.4	0.8
10 < d ≤ 10.5	0.0	0.2	0.2	0.2	0.2	0.6
10.5 < d ≤ 11	0.0	0.0	0.2	0.0	0.2	0.2
11 < d ≤ 11.5	0.4	0.0	0.0	0.0	0.0	0.0
11.5 < d ≤ 12	0.0	0.0	0.3	0.0	0.4	0.4

Table A3.3: Equivalent bubble diameter data for the air/water/1% copy paper system flowing through the cocurrent bubble column. The data are sorted by bubble size.

Copy Paper Consistency (%)	1	1	1	1	1	1
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Count	Equivalent Bubble Diameter (mm)					
1	1.08	1.15	1.33	1.06	1.05	1.21
2	1.14	1.20	1.41	1.43	1.13	1.30
3	1.26	1.40	1.49	1.43	1.14	1.32
4	1.26	1.44	1.50	1.50	1.28	1.34
5	1.35	1.49	1.56	1.54	1.28	1.34
6	1.36	1.49	1.56	1.54	1.42	1.36
7	1.43	1.55	1.60	1.55	1.44	1.37
8	1.44	1.55	1.69	1.56	1.45	1.38
9	1.46	1.55	1.69	1.56	1.46	1.39
10	1.48	1.55	1.71	1.57	1.46	1.40
11	1.49	1.55	1.72	1.59	1.49	1.41
12	1.51	1.58	1.72	1.63	1.53	1.43
13	1.53	1.58	1.74	1.65	1.58	1.43
14	1.63	1.59	1.74	1.65	1.60	1.43
15	1.63	1.67	1.74	1.66	1.62	1.43
16	1.64	1.68	1.75	1.69	1.62	1.45
17	1.71	1.70	1.75	1.69	1.63	1.45
18	1.71	1.71	1.77	1.71	1.66	1.47
19	1.72	1.76	1.79	1.73	1.68	1.48
20	1.73	1.80	1.81	1.77	1.69	1.48
21	1.73	1.80	1.81	1.78	1.70	1.48
22	1.74	1.81	1.82	1.78	1.71	1.51
23	1.75	1.81	1.83	1.79	1.73	1.52
24	1.76	1.82	1.84	1.79	1.75	1.52
25	1.77	1.83	1.85	1.80	1.76	1.54
26	1.77	1.83	1.87	1.84	1.76	1.54
27	1.77	1.84	1.88	1.84	1.76	1.54
28	1.79	1.84	1.89	1.85	1.76	1.55
29	1.80	1.87	1.91	1.85	1.77	1.56
30	1.82	1.89	1.92	1.86	1.78	1.56
31	1.83	1.89	1.94	1.87	1.78	1.57
32	1.84	1.91	1.94	1.90	1.78	1.58
33	1.84	1.91	1.94	1.90	1.81	1.59
34	1.85	1.92	1.95	1.91	1.84	1.59
35	1.87	1.93	1.96	1.93	1.85	1.60
36	1.88	1.93	1.97	1.93	1.86	1.60
37	1.88	1.94	1.99	1.94	1.87	1.60
38	1.91	1.95	1.99	1.94	1.87	1.61
39	1.91	1.96	1.99	1.95	1.90	1.63
40	1.91	1.99	2.01	1.95	1.90	1.63
41	1.91	2.00	2.03	1.96	1.91	1.63
42	1.93	2.00	2.04	1.96	1.92	1.64
43	1.96	2.02	2.04	1.97	1.92	1.64
44	1.97	2.03	2.05	1.97	1.93	1.65
45	1.97	2.03	2.07	1.97	1.94	1.66
46	1.97	2.07	2.10	1.97	1.94	1.68
47	1.98	2.07	2.10	1.98	1.94	1.71
48	2.00	2.10	2.11	2.00	1.95	1.71
49	2.01	2.11	2.11	2.00	1.95	1.71
50	2.04	2.13	2.13	2.00	1.96	1.72
51	2.05	2.14	2.13	2.01	1.97	1.74
52	2.06	2.14	2.13	2.01	1.97	1.74
53	2.07	2.14	2.14	2.02	1.98	1.75
54	2.07	2.14	2.14	2.03	2.00	1.75
55	2.07	2.15	2.14	2.04	2.00	1.76
56	2.07	2.15	2.15	2.04	2.00	1.76
57	2.08	2.15	2.16	2.06	2.00	1.76
58	2.09	2.16	2.17	2.06	2.01	1.78
59	2.09	2.17	2.19	2.07	2.02	1.78
60	2.09	2.17	2.19	2.07	2.04	1.78
61	2.10	2.20	2.22	2.07	2.06	1.79
62	2.10	2.20	2.22	2.07	2.11	1.80
63	2.16	2.20	2.22	2.07	2.12	1.81
64	2.17	2.20	2.23	2.07	2.13	1.83
65	2.18	2.21	2.25	2.08	2.14	1.83
66	2.19	2.22	2.26	2.08	2.14	1.84
67	2.21	2.22	2.26	2.09	2.15	1.84
68	2.21	2.23	2.26	2.10	2.17	1.84
69	2.21	2.23	2.27	2.11	2.18	1.85
70	2.21	2.25	2.27	2.11	2.18	1.85
71	2.22	2.25	2.27	2.11	2.18	1.86
72	2.24	2.26	2.29	2.11	2.18	1.87
73	2.24	2.27	2.30	2.12	2.19	1.87
74	2.25	2.27	2.30	2.12	2.19	1.89
75	2.27	2.29	2.31	2.12	2.20	1.90
76	2.27	2.31	2.32	2.13	2.22	1.90
77	2.30	2.31	2.33	2.13	2.22	1.91
78	2.31	2.32	2.34	2.14	2.22	1.91
79	2.31	2.32	2.34	2.14	2.25	1.91
80	2.31	2.33	2.35	2.14	2.25	1.93
81	2.33	2.33	2.35	2.16	2.27	1.93
82	2.33	2.35	2.37	2.16	2.27	1.93
83	2.34	2.35	2.37	2.16	2.27	1.95
84	2.36	2.35	2.37	2.17	2.27	1.96
85	2.37	2.39	2.38	2.17	2.28	1.97
86	2.37	2.39	2.38	2.18	2.29	1.98
87	2.37	2.39	2.38	2.19	2.29	1.98
88	2.39	2.41	2.39	2.19	2.29	1.99
89	2.39	2.41	2.40	2.20	2.30	2.00
90	2.39	2.41	2.40	2.20	2.30	2.00
91	2.40	2.42	2.40	2.20	2.30	2.01
92	2.43	2.46	2.42	2.22	2.30	2.03
93	2.43	2.46	2.42	2.22	2.31	2.03
94	2.43	2.47	2.42	2.22	2.32	2.04
95	2.44	2.48	2.42	2.23	2.32	2.04
96	2.44	2.48	2.43	2.23	2.34	2.05
97	2.45	2.49	2.43	2.24	2.34	2.06
98	2.46	2.49	2.44	2.24	2.36	2.06
99	2.47	2.49	2.44	2.25	2.36	2.06
100	2.48	2.50	2.45	2.25	2.37	2.06
101	2.48	2.51	2.45	2.25	2.37	2.07
102	2.49	2.51	2.46	2.26	2.39	2.07
103	2.49	2.52	2.46	2.26	2.39	2.07
104	2.49	2.52	2.47	2.26	2.39	2.08
105	2.50	2.53	2.47	2.27	2.39	2.08
106	2.51	2.53	2.47	2.27	2.40	2.10
107	2.52	2.54	2.47	2.27	2.40	2.10
108	2.53	2.55	2.48	2.28	2.41	2.10
109	2.54	2.55	2.48	2.28	2.41	2.10
110	2.55	2.55	2.49	2.28	2.42	2.12
111	2.56	2.55	2.49	2.29	2.42	2.12
112	2.57	2.56	2.50	2.29	2.42	2.12
113	2.58	2.56	2.50	2.30	2.42	2.14
114	2.58	2.57	2.50	2.30	2.43	2.16
115	2.59	2.57	2.51	2.31	2.43	2.17
116	2.59	2.57	2.51	2.31	2.44	2.17
117	2.60	2.58	2.51	2.32	2.44	2.17
118	2.61	2.58	2.53	2.32	2.44	2.18
119	2.61	2.59	2.53	2.32	2.45	2.18
120	2.62	2.59	2.53	2.33	2.45	2.19
121	2.62	2.60	2.53	2.33	2.46	2.19
122	2.62	2.62	2.54	2.33	2.46	2.19
123	2.63	2.62	2.54	2.34	2.46	2.20
124	2.63	2.63	2.54	2.35	2.46	2.20
125	2.64	2.63	2.55	2.36	2.47	2.20
126	2.65	2.63	2.55	2.36	2.50	2.21

Table A3.3: cont.

127	2.66	2.63	2.55	2.37	2.50	2.21
128	2.67	2.65	2.56	2.37	2.51	2.21
129	2.68	2.65	2.56	2.38	2.52	2.22
130	2.70	2.66	2.56	2.38	2.52	2.22
131	2.71	2.66	2.56	2.39	2.52	2.22
132	2.71	2.66	2.56	2.40	2.53	2.22
133	2.73	2.66	2.57	2.42	2.53	2.22
134	2.74	2.67	2.57	2.43	2.53	2.22
135	2.74	2.67	2.57	2.43	2.54	2.23
136	2.75	2.69	2.58	2.43	2.55	2.23
137	2.78	2.69	2.58	2.44	2.58	2.23
138	2.78	2.69	2.59	2.44	2.58	2.23
139	2.80	2.69	2.59	2.45	2.58	2.24
140	2.86	2.70	2.59	2.46	2.58	2.24
141	2.86	2.71	2.59	2.46	2.59	2.25
142	2.86	2.71	2.60	2.47	2.59	2.25
143	2.87	2.71	2.60	2.47	2.60	2.25
144	2.89	2.72	2.60	2.47	2.62	2.26
145	2.90	2.73	2.61	2.47	2.62	2.26
146	2.90	2.73	2.61	2.48	2.62	2.26
147	2.92	2.73	2.61	2.48	2.63	2.27
148	2.92	2.73	2.62	2.49	2.65	2.27
149	2.93	2.73	2.62	2.49	2.66	2.28
150	2.93	2.73	2.62	2.49	2.67	2.28
151	2.94	2.74	2.63	2.49	2.67	2.28
152	2.97	2.75	2.64	2.49	2.67	2.28
153	2.97	2.77	2.64	2.49	2.68	2.30
154	2.97	2.77	2.65	2.52	2.70	2.31
155	2.98	2.78	2.66	2.53	2.70	2.31
156	2.99	2.79	2.66	2.53	2.70	2.32
157	3.00	2.79	2.67	2.54	2.71	2.33
158	3.00	2.79	2.67	2.55	2.71	2.34
159	3.01	2.80	2.67	2.55	2.72	2.34
160	3.02	2.80	2.67	2.56	2.72	2.34
161	3.02	2.80	2.68	2.56	2.73	2.35
162	3.05	2.82	2.68	2.56	2.73	2.35
163	3.07	2.83	2.68	2.57	2.73	2.35
164	3.08	2.83	2.69	2.57	2.73	2.35
165	3.08	2.84	2.70	2.59	2.73	2.35
166	3.11	2.84	2.70	2.59	2.74	2.36
167	3.12	2.85	2.71	2.59	2.74	2.37
168	3.12	2.85	2.71	2.59	2.76	2.37
169	3.13	2.85	2.71	2.59	2.77	2.38
170	3.13	2.85	2.71	2.60	2.77	2.38
171	3.15	2.86	2.72	2.60	2.77	2.38
172	3.16	2.87	2.72	2.60	2.79	2.38
173	3.18	2.87	2.72	2.61	2.79	2.38
174	3.20	2.88	2.73	2.62	2.82	2.39
175	3.23	2.90	2.73	2.62	2.82	2.39
176	3.25	2.90	2.74	2.62	2.82	2.40
177	3.27	2.92	2.74	2.62	2.83	2.41
178	3.27	2.92	2.75	2.62	2.83	2.42
179	3.29	2.93	2.75	2.63	2.84	2.43
180	3.31	2.94	2.75	2.63	2.85	2.44
181	3.32	2.95	2.75	2.65	2.85	2.44
182	3.34	2.95	2.75	2.65	2.86	2.44
183	3.34	2.96	2.75	2.66	2.87	2.45
184	3.35	2.98	2.75	2.67	2.87	2.45
185	3.36	2.98	2.75	2.67	2.89	2.45
186	3.41	2.98	2.76	2.68	2.89	2.45
187	3.41	2.98	2.76	2.68	2.89	2.46
188	3.41	2.98	2.77	2.69	2.90	2.46
189	3.41	3.00	2.77	2.69	2.90	2.47
190	3.41	3.00	2.77	2.69	2.91	2.47
191	3.45	3.00	2.79	2.70	2.91	2.48
192	3.46	3.00	2.79	2.70	2.91	2.48
193	3.46	3.01	2.79	2.70	2.92	2.48
194	3.47	3.01	2.79	2.70	2.92	2.51
195	3.48	3.02	2.79	2.72	2.92	2.52
196	3.48	3.02	2.80	2.72	2.93	2.52
197	3.49	3.03	2.80	2.74	2.95	2.53
198	3.49	3.03	2.80	2.74	2.95	2.54
199	3.50	3.06	2.80	2.74	2.96	2.54
200	3.57	3.07	2.80	2.75	2.98	2.54
201	3.61	3.08	2.81	2.75	2.99	2.55
202	3.62	3.08	2.82	2.75	2.99	2.55
203	3.64	3.08	2.82	2.76	3.00	2.57
204	3.66	3.09	2.83	2.76	3.00	2.58
205	3.74	3.10	2.83	2.76	3.03	2.58
206	3.77	3.11	2.83	2.77	3.03	2.59
207	3.78	3.12	2.83	2.78	3.04	2.60
208	3.80	3.12	2.84	2.78	3.04	2.60
209	3.80	3.12	2.84	2.78	3.05	2.60
210	3.83	3.13	2.86	2.79	3.06	2.61
211	3.83	3.13	2.86	2.79	3.06	2.61
212	3.94	3.15	2.86	2.80	3.06	2.61
213	3.95	3.16	2.87	2.80	3.07	2.61
214	3.96	3.16	2.87	2.80	3.07	2.64
215	3.97	3.16	2.87	2.81	3.07	2.65
216	4.05	3.17	2.87	2.82	3.08	2.65
217	4.09	3.17	2.87	2.82	3.09	2.65
218	4.11	3.17	2.88	2.83	3.10	2.66
219	4.11	3.18	2.88	2.83	3.11	2.67
220	4.13	3.19	2.89	2.83	3.11	2.68
221	4.17	3.20	2.89	2.83	3.11	2.69
222	4.25	3.22	2.89	2.84	3.11	2.69
223	4.26	3.22	2.89	2.84	3.12	2.70
224	4.26	3.22	2.90	2.85	3.12	2.71
225	4.29	3.22	2.90	2.86	3.14	2.73
226	4.30	3.22	2.90	2.86	3.14	2.73
227	4.32	3.23	2.91	2.86	3.15	2.74
228	4.35	3.24	2.91	2.86	3.15	2.75
229	4.35	3.24	2.91	2.86	3.15	2.75
230	4.39	3.24	2.91	2.88	3.15	2.76
231	4.39	3.24	2.91	2.89	3.16	2.76
232	4.43	3.26	2.92	2.89	3.16	2.79
233	4.44	3.27	2.92	2.89	3.17	2.79
234	4.44	3.29	2.92	2.90	3.17	2.81
235	4.45	3.29	2.92	2.90	3.17	2.81
236	4.55	3.29	2.93	2.91	3.18	2.82
237	4.60	3.30	2.93	2.91	3.18	2.83
238	4.64	3.30	2.94	2.91	3.19	2.83
239	4.67	3.31	2.94	2.92	3.19	2.83
240	4.68	3.31	2.94	2.92	3.19	2.83
241	4.75	3.32	2.94	2.93	3.20	2.84
242	4.82	3.32	2.95	2.94	3.20	2.84
243	4.83	3.32	2.96	2.95	3.21	2.84
244	4.87	3.33	2.96	2.96	3.21	2.84
245	4.89	3.34	2.96	2.96	3.22	2.85
246	4.95	3.34	2.97	2.97	3.23	2.85
247	4.96	3.36	2.97	2.97	3.24	2.86
248	5.11	3.36	2.97	2.97	3.24	2.86
249	5.33	3.36	2.97	2.98	3.24	2.86
250	5.41	3.37	2.97	2.98	3.27	2.87
251	5.47	3.37	2.98	2.98	3.27	2.87
252	5.59	3.37	2.99	2.98	3.28	2.88
253	5.61	3.37	2.99	3.02	3.28	2.88
254	5.81	3.38	2.99	3.04	3.29	2.89
255	6.03	3.38	3.00	3.04	3.33	2.89
256	6.76	3.38	3.00	3.06	3.34	2.89
257	7.99	3.39	3.01	3.07	3.35	2.89
258	11.41	3.40	3.01	3.07	3.36	2.90
259	22.33	3.42	3.02	3.07	3.36	2.90
260	25.19	3.42	3.02	3.07	3.38	2.92
261	30.02	3.42	3.02	3.08	3.39	2.93
262	31.53	3.43	3.03	3.08	3.39	2.94
263	33.92	3.43	3.03	3.08	3.39	2.94
264	37.53	3.43	3.03	3.10	3.40	2.94
265	39.14	3.44	3.03	3.12	3.40	2.96

Table A3.3: cont.

266	40.26	3.46	3.04	3.12	3.40	2.97
267	40.79	3.46	3.04	3.13	3.42	2.98
268		3.46	3.04	3.14	3.43	2.99
269		3.47	3.04	3.19	3.44	3.00
270		3.47	3.06	3.20	3.44	3.01
271		3.47	3.07	3.20	3.45	3.02
272		3.48	3.07	3.20	3.45	3.02
273		3.48	3.07	3.21	3.47	3.03
274		3.48	3.07	3.21	3.47	3.03
275		3.48	3.07	3.21	3.48	3.03
276		3.49	3.08	3.22	3.50	3.04
277		3.49	3.08	3.23	3.52	3.05
278		3.50	3.09	3.24	3.53	3.05
279		3.51	3.09	3.25	3.54	3.05
280		3.51	3.09	3.25	3.54	3.06
281		3.52	3.09	3.27	3.54	3.06
282		3.52	3.09	3.28	3.54	3.07
283		3.52	3.10	3.30	3.55	3.08
284		3.53	3.10	3.30	3.55	3.10
285		3.54	3.11	3.31	3.56	3.11
286		3.54	3.11	3.31	3.56	3.11
287		3.54	3.11	3.31	3.58	3.12
288		3.55	3.11	3.32	3.62	3.14
289		3.55	3.11	3.32	3.62	3.17
290		3.57	3.12	3.34	3.63	3.18
291		3.57	3.12	3.34	3.64	3.18
292		3.57	3.13	3.35	3.65	3.18
293		3.57	3.13	3.36	3.66	3.19
294		3.57	3.13	3.37	3.66	3.19
295		3.58	3.14	3.38	3.67	3.20
296		3.58	3.14	3.38	3.71	3.20
297		3.62	3.15	3.39	3.71	3.20
298		3.62	3.15	3.43	3.73	3.22
299		3.63	3.15	3.43	3.73	3.22
300		3.63	3.15	3.43	3.74	3.23
301		3.64	3.16	3.44	3.74	3.23
302		3.66	3.16	3.44	3.77	3.24
303		3.67	3.16	3.45	3.77	3.25
304		3.67	3.17	3.46	3.77	3.25
305		3.68	3.17	3.46	3.77	3.26
306		3.68	3.17	3.48	3.78	3.28
307		3.69	3.18	3.49	3.79	3.33
308		3.69	3.18	3.50	3.80	3.33
309		3.71	3.19	3.50	3.80	3.34
310		3.71	3.19	3.53	3.81	3.35
311		3.72	3.19	3.53	3.82	3.35
312		3.74	3.20	3.55	3.83	3.38
313		3.74	3.20	3.55	3.84	3.42
314		3.74	3.21	3.55	3.85	3.42
315		3.74	3.22	3.56	3.85	3.42
316		3.75	3.22	3.57	3.86	3.43
317		3.75	3.22	3.58	3.89	3.44
318		3.75	3.23	3.59	3.91	3.49
319		3.75	3.23	3.59	3.91	3.50
320		3.76	3.23	3.59	3.91	3.53
321		3.77	3.24	3.60	3.93	3.53
322		3.78	3.24	3.61	3.94	3.56
323		3.80	3.25	3.62	3.95	3.56
324		3.80	3.25	3.63	3.97	3.57
325		3.81	3.25	3.63	3.98	3.57
326		3.83	3.26	3.63	3.99	3.58
327		3.84	3.26	3.63	3.99	3.58
328		3.87	3.27	3.63	3.99	3.59
329		3.90	3.27	3.65	4.00	3.59
330		3.90	3.27	3.65	4.00	3.60
331		3.92	3.27	3.67	4.01	3.62
332		3.93	3.28	3.68	4.01	3.63
333		3.94	3.28	3.69	4.01	3.63
334		3.94	3.28	3.69	4.02	3.64
335		3.94	3.28	3.71	4.02	3.64
336		3.94	3.29	3.74	4.02	3.64
337		3.95	3.29	3.74	4.03	3.66
338		3.97	3.29	3.75	4.03	3.67
339		3.99	3.29	3.76	4.03	3.67
340		4.02	3.29	3.76	4.07	3.69
341		4.04	3.31	3.76	4.08	3.69
342		4.05	3.33	3.82	4.10	3.69
343		4.05	3.33	3.83	4.13	3.71
344		4.06	3.33	3.83	4.14	3.73
345		4.07	3.34	3.83	4.15	3.73
346		4.08	3.34	3.85	4.15	3.73
347		4.09	3.37	3.86	4.16	3.75
348		4.09	3.37	3.87	4.16	3.76
349		4.12	3.37	3.88	4.17	3.77
350		4.13	3.38	3.89	4.18	3.77
351		4.15	3.39	3.89	4.18	3.79
352		4.21	3.40	3.89	4.18	3.83
353		4.21	3.40	3.90	4.19	3.84
354		4.21	3.41	3.96	4.19	3.85
355		4.22	3.41	3.98	4.24	3.85
356		4.23	3.41	3.98	4.25	3.86
357		4.26	3.41	4.00	4.25	3.86
358		4.26	3.42	4.02	4.25	3.86
359		4.26	3.42	4.02	4.26	3.86
360		4.26	3.42	4.08	4.28	3.86
361		4.33	3.43	4.09	4.29	3.87
362		4.34	3.44	4.11	4.30	3.87
363		4.35	3.45	4.11	4.30	3.88
364		4.37	3.46	4.14	4.31	3.88
365		4.37	3.47	4.15	4.31	3.88
366		4.38	3.48	4.16	4.36	3.89
367		4.40	3.49	4.17	4.37	3.91
368		4.41	3.49	4.17	4.38	3.97
369		4.42	3.50	4.20	4.41	4.02
370		4.42	3.51	4.20	4.46	4.03
371		4.42	3.52	4.20	4.47	4.04
372		4.43	3.52	4.21	4.47	4.05
373		4.46	3.52	4.21	4.48	4.05
374		4.46	3.52	4.26	4.49	4.09
375		4.49	3.52	4.26	4.49	4.11
376		4.51	3.52	4.28	4.49	4.12
377		4.55	3.53	4.28	4.51	4.13
378		4.62	3.53	4.28	4.51	4.14
379		4.65	3.53	4.32	4.52	4.14
380		4.67	3.54	4.33	4.52	4.15
381		4.68	3.54	4.34	4.53	4.16
382		4.71	3.54	4.34	4.53	4.16
383		4.75	3.55	4.35	4.54	4.17
384		4.76	3.55	4.43	4.56	4.18
385		4.77	3.56	4.43	4.58	4.18
386		4.81	3.56	4.44	4.60	4.21
387		4.81	3.56	4.50	4.65	4.23
388		4.81	3.57	4.50	4.66	4.24
389		4.82	3.57	4.53	4.66	4.25
390		4.82	3.58	4.57	4.68	4.25
391		4.83	3.59	4.58	4.69	4.30
392		4.85	3.59	4.60	4.70	4.30
393		4.88	3.60	4.60	4.70	4.32
394		4.89	3.60	4.61	4.72	4.33
395		4.91	3.61	4.62	4.75	4.34
396		5.06	3.62	4.63	4.80	4.34
397		5.08	3.63	4.66	4.82	4.35
398		5.08	3.64	4.67	4.82	4.37
399		5.08	3.64	4.69	4.85	4.37
400		5.16	3.64	4.71	4.87	4.42
401		5.18	3.65	4.73	4.93	4.43
402		5.18	3.67	4.74	4.96	4.47
403		5.20	3.69	4.76	4.97	4.47
404		5.22	3.69	4.76	4.98	4.48

Table A3.3: cont.

405		5.24	3.70	4.77	4.99	4.51
406		5.45	3.72	4.77	5.00	4.51
407		5.46	3.74	4.78	5.00	4.52
408		5.46	3.74	4.80	5.07	4.52
409		5.63	3.75	4.82	5.11	4.53
410		5.70	3.76	4.85	5.14	4.55
411		5.77	3.76	4.86	5.15	4.62
412		5.79	3.77	4.86	5.15	4.63
413		5.83	3.77	4.86	5.15	4.64
414		5.90	3.78	4.88	5.16	4.64
415		5.94	3.79	4.89	5.18	4.66
416		6.10	3.79	4.91	5.22	4.67
417		6.24	3.80	4.94	5.23	4.73
418		6.28	3.81	4.95	5.26	4.75
419		6.37	3.82	4.99	5.27	4.77
420		6.76	3.84	4.99	5.27	4.78
421		6.88	3.84	5.00	5.27	4.79
422		7.03	3.84	5.02	5.28	4.86
423		7.29	3.84	5.02	5.30	4.87
424		7.57	3.85	5.03	5.37	4.88
425		7.74	3.85	5.04	5.39	4.91
426		8.06	3.86	5.05	5.42	4.94
427		8.12	3.86	5.06	5.51	4.99
428		9.46	3.86	5.10	5.54	5.00
429		9.49	3.87	5.13	5.55	5.01
430		10.28	3.88	5.13	5.58	5.04
431		16.69	3.88	5.14	5.60	5.17
432		20.48	3.89	5.15	5.62	5.20
433		24.16	3.89	5.19	5.62	5.28
434		32.93	3.90	5.24	5.66	5.28
435		34.17	3.90	5.26	5.69	5.28
436		37.51	3.93	5.34	5.71	5.31
437		38.31	3.94	5.39	5.72	5.34
438		39.04	3.94	5.40	5.74	5.51
439		40.39	3.95	5.41	5.77	5.60
440		41.67	3.95	5.42	5.77	5.63
441		48.07	3.97	5.43	5.78	5.65
442			3.98	5.44	5.80	5.66
443			3.98	5.45	5.81	5.73
444			3.98	5.50	5.81	5.75
445			3.99	5.54	5.83	5.95
446			4.00	5.54	5.85	5.95
447			4.00	5.55	5.88	5.96
448			4.01	5.58	5.89	6.00
449			4.04	5.60	5.93	6.15
450			4.05	5.74	5.94	6.25
451			4.06	5.78	5.94	6.28
452			4.07	5.87	6.02	6.33
453			4.09	5.88	6.04	6.36
454			4.10	5.93	6.05	6.52
455			4.10	5.95	6.07	6.54
456			4.11	5.95	6.08	6.57
457			4.12	6.03	6.12	6.65
458			4.13	6.14	6.12	6.69
459			4.13	6.17	6.13	6.90
460			4.14	6.18	6.15	7.20
461			4.15	6.24	6.17	7.27
462			4.15	6.26	6.31	7.29
463			4.16	6.42	6.31	7.35
464			4.16	6.44	6.38	7.57
465			4.17	6.57	6.44	8.15
466			4.17	6.86	6.50	8.17
467			4.17	6.99	6.56	8.20
468			4.18	7.25	6.64	8.30
469			4.18	7.29	6.65	8.49
470			4.18	7.37	6.72	8.50
471			4.18	7.37	6.81	8.65
472			4.19	7.38	6.82	8.67
473			4.20	7.39	6.84	8.94
474			4.21	7.83	6.88	8.95
475			4.21	7.85	7.02	8.99
476			4.21	8.43	7.04	9.56
477			4.22	8.80	7.19	9.61
478			4.22	9.13	7.41	9.64
479			4.22	9.31	7.44	9.92
480			4.23	9.73	7.46	10.03
481			4.24	9.86	7.53	10.11
482			4.26	10.32	7.65	10.31
483			4.26	12.01	7.70	10.51
484			4.28	12.04	7.88	11.85
485			4.29	12.44	7.91	11.92
486			4.29	13.78	8.22	12.02
487			4.31	14.14	8.43	12.41
488			4.31	15.29	8.50	12.49
489			4.31	15.67	8.62	17.14
490			4.33	33.43	9.06	20.17
491			4.34	42.63	9.36	28.36
492			4.34	44.10	9.41	30.15
493			4.35	51.18	9.87	67.80
494			4.37	52.28	9.94	74.46
495			4.39		10.19	76.13
496			4.39		10.71	96.52
497			4.40		11.71	
498			4.41		12.00	
499			4.41		12.12	
500			4.42		13.09	
501			4.42		13.12	
502			4.44		13.33	
503			4.44		15.22	
504			4.45		16.81	
505			4.47		17.21	
506			4.47		17.74	
507			4.49		18.01	
508			4.49		19.17	
509			4.49		44.03	
510			4.50		62.14	
511			4.51			
512			4.51			
513			4.52			
514			4.52			
515			4.55			
516			4.56			
517			4.57			
518			4.58			
519			4.59			
520			4.59			
521			4.60			
522			4.64			
523			4.66			
524			4.67			
525			4.67			
526			4.69			
527			4.76			
528			4.77			
529			4.78			
530			4.79			
531			4.80			
532			4.82			
533			4.82			
534			4.83			
535			4.83			
536			4.83			
537			4.86			
538			4.87			
539			4.88			
540			4.91			
541			4.92			
542			4.92			
543			4.94			

Table A3.3: cont.

544			4.94			
545			4.95			
546			5.00			
547			5.02			
548			5.03			
549			5.04			
550			5.09			
551			5.11			
552			5.12			
553			5.14			
554			5.19			
555			5.22			
556			5.26			
557			5.31			
558			5.31			
559			5.31			
560			5.33			
561			5.34			
562			5.34			
563			5.36			
564			5.49			
565			5.51			
566			5.52			
567			5.52			
568			5.53			
569			5.56			
570			5.57			
571			5.58			
572			5.59			
573			5.64			
574			5.64			
575			5.67			
576			5.70			
577			5.71			
578			5.74			
579			5.84			
580			5.92			
581			6.01			
582			6.03			
583			6.07			
584			6.07			
585			6.10			
586			6.12			
587			6.21			
588			6.28			
589			6.29			
590			6.46			
591			6.55			
592			6.60			
593			6.62			
594			6.66			
595			6.73			
596			6.75			
597			6.80			
598			6.90			
599			6.94			
600			6.98			
601			6.99			
602			6.99			
603			7.01			
604			7.03			
605			7.08			
606			7.12			
607			7.32			
608			7.65			
609			7.68			
610			7.81			
611			7.82			
612			7.89			
613			7.91			
614			8.22			
615			8.72			
616			9.18			
617			9.54			
618			10.47			
619			10.55			
620			11.54			
621			11.65			
622			12.59			
623			12.79			
624			15.35			
625			15.58			
626			18.50			
627			25.13			
628			27.66			
629			28.79			
630			31.15			
631			35.10			
632			39.94			
633			41.03			
634			41.50			
635			45.15			
636			55.94			
637			67.30			

Appendix A4 - Equivalent Bubble Size Measurements for the Air/Water/1.5% Copy Paper System

This appendix tabulates the equivalent bubble diameter measurements recorded for the air/water/1.5% copy paper system flowing through the cocurrent bubble column. Table A4.1 summarizes the equivalent bubble diameter number density for all bubble diameters. Table A4.2 tabulates the equivalent bubble diameter number density for all data with $d \leq 12$ mm. Table A4.3 presents all of the equivalent bubble diameter measurements obtained from the FXR images.

Table A4.1: Summary of the equivalent bubble diameter number density for all the air/water/1.5% copy paper data obtained in this study.

Copy Paper Consistency (%)	[illegible]	[illegible]	1.5	1.5	1.5	1.5
Column Position (cm)	15-40	15 15-40	15 15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
0 < d ≤ 1	00 .	00 .	00 .	00 .	00 .	00 .
1 < d ≤ 1.5	26 .	08 .	09 .	08 .	19 .	00 .
1.5 < d ≤ 2	09 .	4.0	05 .	2.4	5.2	7.0
2 < d ≤ 2.5	13.2	10.5	7.9	12 1	14.8	16.9
2.5 < d ≤ 3	18.4	14.5	12.5	25.0	15.7	16.9
3 < d ≤ 3.5	12.3	12.1	13.4	17.7	90 .	15.3
3.5 < d ≤ 4	13.2	12.1	13.9	65 .	76 .	95 .
4 < d ≤ 4.5	10.5	7.;	12.5.	89 .	62 .	37 .
4.5 < d ≤ 5	53 .	48 .	74 .	24 .	71 .	58 .
5 c d ≤ 5.5	26 .	65 .	51 .	32 .	76 .	29 .
5.5 < d ≤ 6	44 .	16 .	32 .	40 .	24 .	29 .
6 < d ≤ 6.5	18 .	16 .	14 .	24 .	19 .	25 .
6.5 < d ≤ 7	26 .	48 .	32 .	32 .	24 .	17 .
7 < d ≤ 7.5	00 .	00 .	19 .	00 .	05 .	17 .
7.5 < d ≤ 8	09 .	16 .	14 .	08 .	19 .	17 .
8 < d ≤ 8.5	00 .	08 .	14 .	08 .	19 .	00 .
8.5 < d ≤ 9	18 .	16 .	19 .	00 .	10 .	04 .
9 < d ≤ 9.5	00 .	16 .	19 .	08 .	19 .	04 .
9.5 < d ≤ 10	09 .	08 .	09 .	00 .	19 .	08 .
10 < d ≤ 10.5	18 .	00 .	00 .	08 .	10 .	21 .
10.5 < d ≤ 11	00 .	00 .	[illegible]	[illegible]	14 .	08 .
11 < d ≤ 11.5	00 .	08 .	00 .	08 .	05 .	04 .
11.5 < d ≤ 12	00 .	0.8	00 .	00 .	00 .	04 .
d > 12	70 .	11.3.	79 .	73 .	62 .	62 .

Table A4.2: Summary of the equivalent bubble diameter number density for the d ≤ 12 mm air/water/1.5% copy paper data obtained in this study.

Copy Paper Consistency (%)	1.5	1.5	1.5	1.5	1.5	1.5
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Size Range (mm)	Equivalent Bubble Diameter Number Density (%)					
0 < d ≤ 1	00 .	00 .	00 .	00 .	00 .	00 .
1 < d ≤ 1.5	28 .	09 .	10 .	09 .	20 .	00 .
1.5 < d ≤ 2	09 .	47 .	05 .	26 .	56 .	75 .
2 < d ≤ 2.5	14.2	12.3	8.5	13.0	15.7	18.1
2.5 < d ≤ 3	19.8	17.0	**13.6**	27.0	**16.8**	**18.1**
3 < d ≤ 3.5	13.2	14.2	14.6	19.1	9.6	16.3
3.5 < d ≤ 4	14.2	14.2	15.1	7.0	81 .	10.1
4 < d ≤ 4.5	11.3	8.5	13.6	9.6	66 .	40 .
4.5 < d ≤ 5	57 .	57 .	80 .	26 .	76 .	62 .
5 < d ≤ 5.5	28 .	75 .	55 .	35 .	81 .	31 .
5.5 < d ≤ 6	47 .	19 .	35 .	43 .	25 .	31 .
6 < d ≤ 6.5	19 .	19 .	15 .	26 .	20 .	26 .
6.5 < d ≤ 7	28 .	57 .	35 .	35 .	25 .	18 .
7 < d ≤ 7.5	00 .	00 .	20 .	00 .	05 .	18 .
7.5 < d ≤ 8	09 .	19 .	15 .	09 .	20 .	18 .
8 < d ≤ 8.5	00 .	09 .	15 .	09 .	20 .	00 .
8.5 < d ≤ 9	19 .	19 .	20 .	00 .	10 .	04 .
9 < d ≤ 9.5	00 .	19 .	20 .	09 .	20 .	04 .
9.5 < d ≤ 10	09 .	09 .	10 .	00 .	20 .	09 .
10 < d ≤ 10.5	19 .	00 .	00 .	09 .	10 .	22 .
10.5 < d ≤ 11	00 .	00 .	10 .	00 .	15 .	09 .
11 < d ≤ 11.5	00 .	09 .	00 .	09 .	05 .	04 .
11.5 < d ≤ 12	00 .	09 .	00 .	00 .	00 .	04 .

Table A4.3: Equivalent bubble diameter data for the air/water/1.5% copy paper system flowing through the cocurrent bubble column. The data are sorted by bubble size.

Copy Paper Consistency (%)	1.5	1.5	1.5	1.5	1.5	1.5
Column Position (cm)	15-40	15-40	15-40	115-140	115-140	115-140
Superficial Liquid Velocity (cm/s)	2	2	2	2	2	2
Superficial Gas Velocity (cm/s)	1	2	4	1	2	4
Bubble Count	Equivalent Bubble Diameter (mm)					
1	1.36	1.22	1.01	1.48	1.31	1.64
2	1.43	1.54	1.07	1.71	1.36	1.69
3	1.48	1.54	1.91	1.74	1.36	1.71
4	1.63	1.82	2.03	1.77	1.38	1.75
5	2.00	1.83	2.16	2.10	1.56	1.81
6	2.03	1.90	2.17	2.14	1.56	1.83
7	2.04	2.05	2.21	2.16	1.60	1.84
8	2.06	2.15	2.24	2.16	1.73	1.87
9	2.07	2.19	2.27	2.17	1.81	1.89
10	2.13	2.20	2.28	2.24	1.81	1.90
11	2.14	2.20	2.30	2.26	1.83	1.90
12	2.17	2.24	2.33	2.26	1.86	1.94
13	2.18	2.29	2.34	2.27	1.86	1.94
14	2.32	2.29	2.34	2.27	1.87	1.95
15	2.32	2.32	2.39	2.28	1.98	1.95
16	2.35	2.40	2.41	2.31	2.01	1.96
17	2.36	2.41	2.41	2.34	2.08	1.99
18	2.46	2.42	2.43	2.35	2.09	2.01
19	2.49	2.47	2.47	2.43	2.09	2.02
20	2.55	2.50	2.48	2.54	2.10	2.04
21	2.57	2.55	2.54	2.57	2.12	2.10
22	2.58	2.56	2.58	2.59	2.13	2.13
23	2.63	2.60	2.59	2.60	2.14	2.17
24	2.65	2.63	2.60	2.62	2.15	2.17
25	2.71	2.67	2.61	2.63	2.18	2.18
26	2.74	2.67	2.61	2.63	2.19	2.19
27	2.76	2.67	2.63	2.65	2.21	2.19
28	2.79	2.69	2.64	2.65	2.21	2.20
29	2.81	2.72	2.70	2.66	2.21	2.21
30	2.83	2.77	2.70	2.67	2.26	2.21
31	2.90	2.85	2.71	2.68	2.26	2.24
32	2.90	2.86	2.71	2.73	2.27	2.27
33	2.91	2.89	2.75	2.74	2.28	2.28
34	2.97	2.91	2.75	2.75	2.30	2.29
35	2.98	2.91	2.76	2.75	2.30	2.30
36	2.98	2.94	2.77	2.77	2.31	2.31
37	2.98	3.00	2.78	2.79	2.33	2.33
38	2.98	3.01	2.82	2.80	2.37	2.34
39	2.98	3.11	2.85	2.81	2.40	2.34
40	3.00	3.11	2.85	2.82	2.44	2.35
41	3.01	3.12	2.89	2.83	2.44	2.36
42	3.02	3.18	2.90	2.85	2.44	2.36
43	3.12	3.19	2.93	2.90	2.45	2.37
44	3.17	3.26	2.93	2.92	2.46	2.37
45	3.17	3.32	2.96	2.92	2.46	2.37
46	3.21	3.33	2.98	2.95	2.49	2.37
47	3.22	3.34	2.99	2.96	2.52	2.38
48	3.29	3.34	3.02	2.97	2.56	2.38
49	3.33	3.38	3.05	2.97	2.58	2.38
50	3.35	3.43	3.06	2.99	2.59	2.41
51	3.36	3.48	3.08	3.02	2.59	2.41
52	3.39	3.49	3.08	3.04	2.59	2.41
53	3.41	3.51	3.09	3.05	2.62	2.42
54	3.46	3.55	3.11	3.07	2.63	2.42
55	3.53	3.55	3.13	3.07	2.63	2.44
56	3.56	3.56	3.15	3.08	2.67	2.46
57	3.60	3.58	3.15	3.10	2.68	2.49
58	3.65	3.61	3.17	3.12	2.72	2.50
59	3.65	3.69	3.18	3.16	2.73	2.50
60	3.69	3.69	3.20	3.19	2.74	2.51
61	3.70	3.74	3.22	3.21	2.77	2.51
62	3.73	3.80	3.27	3.22	2.78	2.51
63	3.75	3.84	3.29	3.22	2.78	2.53
64	3.82	3.91	3.30	3.27	2.78	2.54
65	3.90	3.93	3.32	3.30	2.79	2.55
66	3.92	3.94	3.32	3.33	2.79	2.55
67	3.94	3.98	3.33	3.40	2.82	2.56
68	4.00	4.00	3.33	3.41	2.82	2.58
69	4.00	4.01	3.34	3.43	2.87	2.59
70	4.06	4.13	3.36	3.45	2.88	2.64
71	4.09	4.19	3.38	3.45	2.88	2.64
72	4.17	4.23	3.40	3.45	2.92	2.66
73	4.23	4.25	3.44	3.58	2.92	2.67
74	4.26	4.35	3.46	3.58	2.93	2.68
75	4.27	4.40	3.48	3.62	2.93	2.69
76	4.29	4.40	3.49	3.67	2.94	2.70
77	4.29	4.65	3.50	3.70	2.94	2.70
78	4.35	4.73	3.57	3.77	2.94	2.71
79	4.42	4.74	3.58	3.78	2.99	2.72
80	4.43	4.76	3.58	3.87	3.03	2.73
81	4.49	4.95	3.58	4.03	3.09	2.74
82	4.51	4.96	3.59	4.03	3.10	2.80
83	4.56	5.04	3.63	4.03	3.16	2.82
84	4.57	5.11	3.65	4.04	3.17	2.83
85	4.61	5.16	3.65	4.15	3.19	2.84
86	4.71	5.16	3.67	4.21	3.21	2.84
87	4.78	5.20	3.69	4.27	3.23	2.86
88	5.05	5.33	3.69	4.29	3.28	2.86
89	5.32	5.36	3.71	4.34	3.30	2.87
90	5.43	5.50	3.73	4.37	3.32	2.87
91	5.69	5.53	3.75	4.39	3.34	2.87
92	5.76	5.66	3.75	4.51	3.35	2.87
93	5.86	6.02	3.78	4.55	3.37	2.88
94	5.92	6.26	3.79	4.60	3.41	2.89
95	5.99	6.55	3.84	5.01	3.41	2.90
96	6.28	6.58	3.84	5.26	3.45	2.90
97	6.30	6.59	3.85	5.45	3.48	2.93
98	6.52	6.64	3.87	5.47	3.49	2.94
99	6.83	6.72	3.87	5.60	3.55	3.00
100	7.00	6.88	3.89	5.61	3.60	3.02
101	7.58	7.61	3.95	5.63	3.64	3.05
102	8.76	8.00	3.95	5.66	3.65	3.05
103	8.89	8.13	3.95	5.85	3.66	3.06
104	9.64	8.65	3.97	6.04	3.67	3.07
105	10.03	8.92	3.98	6.23	3.71	3.07
106	10.34	9.17	3.99	6.47	3.74	3.07
107	13.45	9.20	4.00	6.62	3.75	3.08
108	17.20	9.55	4.01	6.70	3.77	3.09
109	39.72	11.16	4.01	6.84	3.78	3.13
110	40.53	11.89	4.02	6.95	3.81	3.14
111	44.67	13.26	4.02	7.88	3.86	3.15
112	46.09	13.28	4.04	8.45	3.88	3.15
113	50.40	14.02	4.07	9.47	3.88	3.18
114	60.18	14.43	4.07	10.48	3.91	3.18
115		14.78	4.12	11.36	4.02	3.18
116		23.39	4.16	12.15	4.04	3.21
117		27.06	4.19	12.68	4.04	3.25
118		33.44	4.20	15.54	4.05	3.28
119		33.97	4.22	17.32	4.08	3.29
120		37.50	4.23	17.99	4.12	3.29
121		41.90	4.24	26.34	4.16	3.31
122		48.05	4.24	49.86	4.20	3.33
123		52.87	4.24	61.49	4.27	3.33
124		61.61	4.32	62.55	4.30	3.34
125			4.37		4.40	3.37
126			4.37		4.43	3.37

Table A4.3: cont.

127			4.39		4.50	3.39
128			4.40		4.51	3.39
129			4.41		4.52	3.40
130			4.42		4.54	3.41
131			4.45		4.56	3.41
132			4.47		4.58	3.41
133			4.48		4.62	3.45
134			4.52		4.67	3.47
135			4.52		4.75	3.47
136			4.57		4.78	3.47
137			4.59		4.79	3.53
138			4.62		4.81	3.54
139			4.69		4.83	3.54
140			4.69		4.86	3.56
141			4.74		4.87	3.57
142			4.74		4.90	3.58
143			4.76		5.03	3.65
144			4.78		5.05	3.67
145			4.79		5.08	3.67
146			4.83		5.10	3.69
147			4.83		5.12	3.69
148			4.83		5.12	3.72
149			4.90		5.14	3.76
150			5.01		5.24	3.77
151			5.01		5.32	3.79
152			5.04		5.33	3.81
153			5.07		5.33	3.86
154			5.11		5.35	3.87
155			5.15		5.46	3.90
156			5.24		5.47	3.91
157			5.37		5.47	3.93
158			5.40		5.48	3.95
159			5.45		5.51	3.96
160			5.45		5.54	4.01
161			5.53		5.56	4.05
162			5.57		5.66	4.15
163			5.63		5.89	4.25
164			5.72		6.06	4.26
165			5.74		6.26	4.27
166			5.77		6.28	4.34
167			5.98		6.35	4.37
168			6.14		6.53	4.39
169			6.24		6.78	4.56
170			6.29		6.80	4.60
171			6.52		6.93	4.61
172			6.53		6.97	4.65
173			6.54		7.50	4.67
174			6.58		7.51	4.74
175			6.78		7.58	4.76
176			6.93		7.64	4.85
177			6.94		7.96	4.86
178			7.11		8.03	4.88
179			7.37		8.03	4.92
180			7.39		8.15	4.95
181			7.42		8.45	4.95
182			7.56		8.52	5.00
183			7.86		8.87	5.04
184			7.96		9.05	5.08
185			8.17		9.14	5.10
186			8.46		9.16	5.28
187			8.48		9.40	5.31
188			8.55		9.53	5.32
189			8.58		9.65	5.47
190			8.62		9.69	5.53
191			8.69		9.72	5.54
192			9.01		10.29	5.56
193			9.23		10.32	5.57
194			9.31		10.58	5.78
195			9.42		10.70	5.87
196			9.64		10.97	5.96
197			9.89		11.05	6.05
198			10.60		12.52	6.09
199			10.93		13.85	6.13
200			12.02		14.07	6.17
201			12.15		14.74	6.22
202			13.18		15.74	6.35
203			13.97		15.87	6.55
204			14.97		16.43	6.63
205			16.06		18.10	6.64
206			17.89		20.26	6.72
207			18.73		21.13	7.07
208			24.21		23.27	7.26
209			25.29		24.16	7.26
210			36.29		36.67	7.34
211			38.31		78.34	7.79
212			45.14			7.79
213			45.55			7.91
214			45.96			7.94
215			49.25			8.53
216			53.86			9.46
217						9.54
218						9.56
219						10.11
220						10.16
221						10.25
222						10.35
223						10.36
224						10.60
225						10.72
226						11.41
227						11.73
228						12.06
229						12.94
230						13.93
231						14.68
232						15.65
233						17.30
234						17.88
235						18.85
236						21.68
237						22.07
238						22.80
239						25.07
240						73.93
241						76.69
242						79.70