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VARIATION OF JP-8 PROPERTIES IN THE CONTINENTAL UNITED STATES (CONUS) AND POTENTIAL IMPLICATIONS DURING BLENDING WITH SYNTHETIC PARAFFIN KEROSENE

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Interim Report

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14. ABSTRACT
Both U.S. military JP-8 and commercial Jet A/A-1 fuel specifications allow blending up to 50 vol. % Synthetic Paraffinic Kerosene (SPK) produced via the Fischer-Tropsch (FT) process with a certification petroleum-derived fuel. Understanding the impact of historical variations of neat JP-8 fuel properties on the resulting fuel blends will assist with implementation. In this effort, statistical analyses were performed using the PQIS database to investigate the variation of selected JP-8 properties as a function of year (1997-2008) and procurement region in CONUS. Properties considered were: Aromatic Content, Density, Freeze Point, Viscosity, Heat of Combustion (by mass), and Volumetric Heating Value. Consistent historical trends were observed for several properties within specific regions, allowing for future prediction. However, statistically significant historical differences exist in certain fuel properties depending on procurement region which requires that the region be considered when estimating the expected fuel properties during blending. Calculations indicated that a substantial probability exists that a 50 vol. % blend will not satisfy the minimum 8.0 vol. % aromatic content and/or 0.775 g/mL density requirements. Probability varied significantly depending upon the procurement region, indicating that solely using the average CONUS property values would result in inaccurate prediction of fuel properties. These analyses provide an initial basis of evaluation for the implementation of alternative fuel blends and the expected maximum volume percentages which can be safely employed. The methodology used during the analyses, the historic JP-8 property trends as a function of procurement region, the property correlations investigated, and analysis and implications of blending JP-8 with SPK are presented. Appendix A includes supplemental statistical analyses and blend calculations. Appendix B contains a concise summary version of this report.

15. SUBJECT TERMS
PQIS, JP-8, Fuel Property, Aromatic Content, Density, Heat of Combustion, Volumetric Heat of Combustion, SPK, Synthetic Paraffinic Kerosene, Fischer-Tropsch Fuel, Blend, Statistical Analysis

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1. Executive Summary

Extensive research and development has recently resulted in the approval in the use of Synthetic Paraffinic Kerosene (SPK) produced via the Fischer-Tropsch (FT) process as a blend feedstock with JP-8 military and Jet A/A-1 commercial fuels. Both U.S. military (MIL-DTL-83133F) and commercial fuel (ASTM D7566-09) specifications currently allow blending up to 50 vol. % SPK with a certification petroleum-derived fuel provided the blend specification requirements are satisfied. In order to facilitate domestic military implementation, it is important to understand the impact of historical variations of neat JP-8 fuel properties on the resulting fuel blends. In this effort, statistical analyses were performed to investigate the variation of selected JP-8 properties as a function of year (1997-2008) and region in the Continental United States (CONUS) in which the fuel was procured. The analyses were performed using the Petroleum Quality Information System (PQIS) database reported annually by the Defense Energy Support Center (DESC). The properties considered included: Aromatic Content, Density, Freeze Point, Viscosity, Heat of Combustion (by mass), and Volumetric Heating Value. Consistent historical trends were observed for several properties within specific regions, which allows for prediction of expected fuel properties in the future. However, the analyses indicated that statistically significant historical differences exist in certain fuel properties, including the total aromatic content and density, depending on the region in which the fuel was procured. These differences require that the region from which JP-8 was procured be considered when estimating the expected fuel properties during blending with SPK. Correlations were found to exist between certain JP-8 properties, which would allow for prediction of one property with knowledge of the other. An interesting observation was the lack of a correlation between the historic measured aromatic content and density values for JP-8.

The implications of blending JP-8 with SPK on the resulting aromatic content and density were studied by performing calculations using the historic PQIS data. Specific effort was made to estimate the probability of a 50 vol. % fuel blend satisfying the specification requirements. Notably, a substantial probability exists that a 50 vol. % blend of JP-8 with SPK will not satisfy the minimum 8.0 vol. % aromatic content and/or 0.775 g/mL density blend specification requirements. The probability varied significantly depending upon the region in which the JP-8 was procured, indicating that solely using the average CONUS property values and variability would result in a significant under-/overestimation of the actual fuel properties. These analyses provide an initial basis of evaluation for the implementation of alternative fuel blends and the expected maximum volume percentages which can be safely employed. Overall, the methodology used during the analyses, the historic JP-8 property trends as a function of procurement region, the property correlations investigated, and analysis and implications of blending JP-8 with SPK are presented and discussed within this report.

The Appendices to this report contain additional data analyses and discussion related to historic variation in JP-8 fuel properties and implications of SPK blending on the resulting aromatic and density values. Appendix A includes three primary sections. The first is an extensive historical statistical analysis for each property evaluated in this report as a function of procurement region, including data plots and comparisons of discrete data to predictions using the best functional form fit. The next section provides a comparison of property correlations using the 2008 PQIS data. The last section presents results from analyses to determine the maximum volume percentage of JP-8 that could be blended with an SPK and still satisfy the

8.0% minimum aromatic or 0.775 g/mL density requirements. These analyses were performed as a function of both year and procurement region, and show the maximum blend percentages which can be implemented for 95, 90 or 80% of the procured JP-8 fuel volume while still satisfying the minimum blend specifications. Appendix B includes a concise summary version of this report with primary conclusions and implications which was presented at the 11th International Conference on Stability, Handling and Use of Liquid Fuels in October, 2009.

2. Introduction

For each shipment of military fuel procured in the United States, the location, volume, and chemical and physical properties of the fuel are recorded by the Defense Energy Support Center (DESC) in the Petroleum Quality Information System (PQIS) database. The DESC separates the Continental United States (CONUS) into five regions for which fuel procurements are tracked, as shown in Figure 1. World-wide fuel procurements (OCONUS) are also recorded as a function of region. DESC procures large volumes of JP-8 for the Department of Defense (DoD) in CONUS, with annual volumes typically between 1.5-2.0 billion gallons. Figure 2 shows the total volume of fuel procured in CONUS as a function of region from 1997-2008. As shown, there are significant differences in the total volume of fuel procured within each CONUS region while the respective percentages are relatively consistent. The majority of fuel is procured in Regions 2, 3 and 5 while Regions 1 and 4 account for a low percentage of the total.

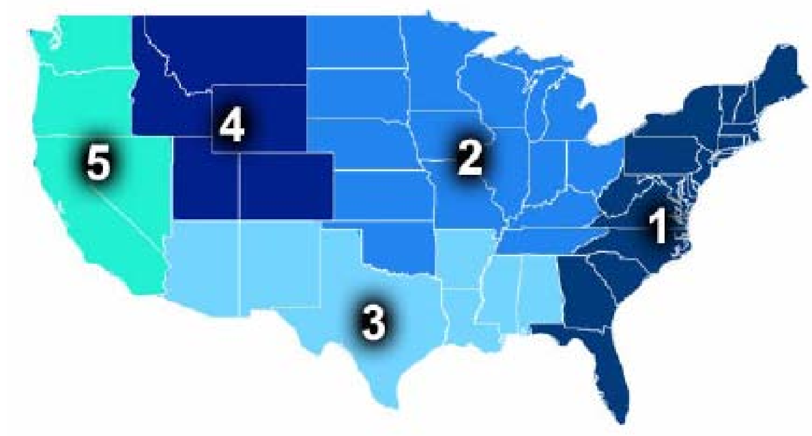

Figure 1. DESC Regions 1-5 of the Continental United States (CONUS).

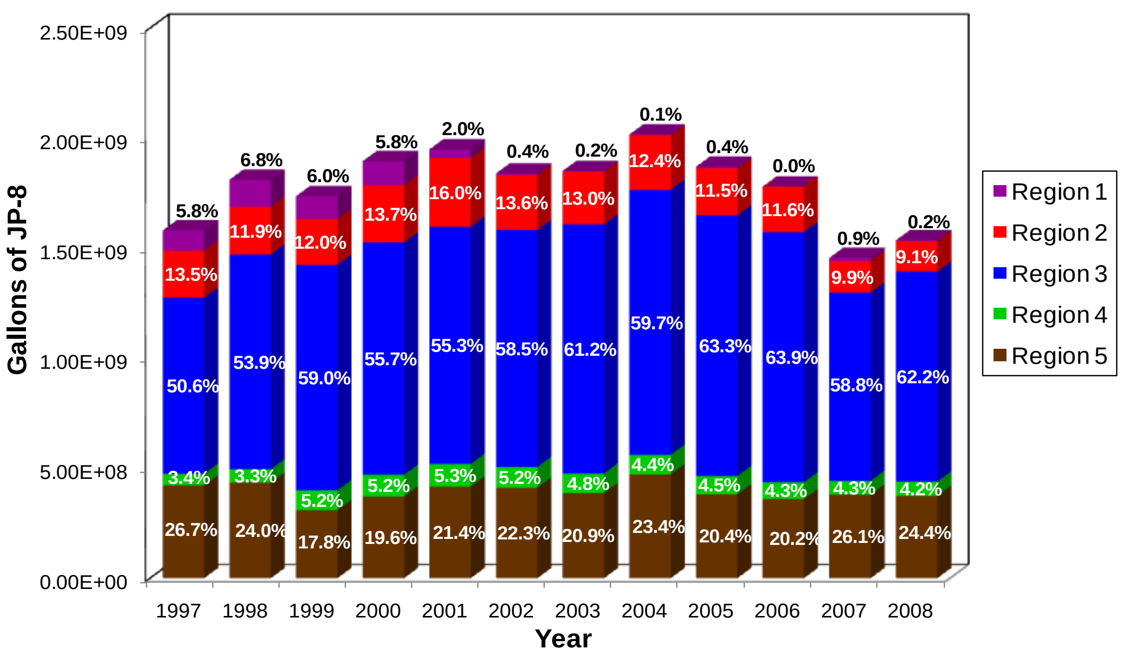

Figure 2. Total Volume of JP-8 Procured in Each Region of CONUS from 1997-2008.

The availability of Synthetic Paraffinic Kerosene (SPK) produced via the Fischer-Tropsch (FT) process has provided a potential supplemental domestic fuel source to the use of petroleum-derived JP-8 fuel. However, due to potential operational issues while employing neat FT fuel directly in legacy and future aircraft and limitations in available quantities, it may be necessary to blend the SPK fuel with JP-8 for implementation. In fact, the JP-8 military fuel specification, MIL-DTL-83133F, was modified (11 April 2008) to allow blending of up to 50% SPK with a certification JP-8. More recently, the use of SPK blends has been approved for use in commercial Jet A and Jet A-1 in ASTM D7566 ("Specification for Aviation Turbine Fuels Containing Synthesized Hydrocarbons") in September 2009. Both specifications require that the resulting mixture must have a minimum aromatic content of 8%, a minimum specific gravity of 0.775 g/mL, and satisfy all other property requirements.

Recent efforts have focused on identifying the effect of blend percentage on the resulting chemical and physical properties.[1-8] Improved understanding of the effect of blending on the resulting properties is needed to insure safe operability of aircraft and allow for implementation of FT-derived fuels. It has been found that the majority of fuel properties vary linearly with blend percentage provided that the SPK has a similar distillation range to a typical jet fuel with a sufficiently high *iso*-/normal alkane ratio. Based on detailed studies and requirements in the JP-8 fuel specification, the JP-8 fuel properties potentially adversely impacted during blending include aromatic content, density, freeze point, viscosity, heat of combustion, and volumetric heating value. Volumetric heating value is not a directly measured specification requirement, but may be important for fuel volume-limited applications and combustion performance due to the inherently lower density for SPK fuels.

Understanding of the effect of blending is very useful since it allows for analysis of historical JP-8 property trends to determine anticipated fuel properties during implementation, including the percentage of potential fuel blends which will satisfy the JP-8 fuel specification requirements. In this effort, an analysis of the PQIS data was performed for the selected fuel properties to investigate time-dependent statistical trends to determine if these JP-8 properties can be predicted in the future. Specifically, the 1999-2008 PQIS data (aromatic content from 1997-2008) were analyzed to determine if the properties of JP-8 fuel vary as a function of year and/or region in which the fuel was procured. The PQIS data was also fit to the probability distribution with the highest correlation for each year within a specific region using Minitab Statistical Software. The distribution fit curves are useful in identifying the existence or lack of trends in specific property values. Using discrete data and trends determined for the neat JP-8 property values and understanding the dependence of these on blending with SPK, the resulting blend properties and maximum allowable percentage of synthetic fuel while still satisfying the JP-8 fuel specifications can be determined. The following section will detail the statistical analyses performed for each fuel property of interest and discuss potential implications of blending of 50% SPK on resulting fuel properties using the property trends identified. Additional analyses and a summary report are included in the Appendices to this report. This effort expands on a previous detailed analysis performed using the 2004 PQIS data.[4]

3. PQIS Historical Data Analysis

3.1. JP-8 Property Analysis for Regions 1-5 of CONUS

The Petroleum Quality Information System (PQIS) data from the years 1999-2008 were analyzed for selected fuel properties (1997-2008 for aromatic content) to identify if there are statistical variances depending upon location of fuel procurement and year. The data was analyzed individually for Regions 1-5 and combined for CONUS (as typically reported in the PQIS Annual Report). In each region, the weight mean, standard deviation, and confidence intervals (95%, 90%, 80%, 70%, and 60%) were calculated for each property as a function of year. The range of values representing 68.26% of the property data fall between ± one standard deviation (1σ) from the weight mean for the normal probability distribution. The larger confidence intervals (95% and 90%) demonstrate the range in the value of a given property since a large percentage of the data falls within these intervals. The smaller confidence intervals (80%, 70% and 60%) show the focal (or center range) in which the value of a given property is likely to exist. In instances where there is little difference in the large and smaller confidence intervals, a large percentage of the random data is centralized around a small range of values. When there are distinct differences in the confidence intervals, the random data usually extends over a wide range of values with the majority of values focused within the 60% confidence interval.

The PQIS data for each year and region were fit using the probability distribution with the highest correlation. Consistency in mean values and trends in data can be readily determined by comparing the distribution fit curves of the random data. The density functions for the relevant probability distributions are represented in Equations 1-5. The probability distributions discussed below are the most commonly used distributions for reliability data to determine trends. Each distribution is a two or three-parameter distribution, which affect the height, width, skewness, and placement of the distribution curve along the x-axis. The distribution parameters used are:

μ	–	Location
σ or α	–	Scale
β	–	Shape
θ	–	Threshold

Normal Probability Distribution:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)} \qquad \text{(Equation 1)}$$

The Normal probability distribution represents random data that is symmetrically distributed about a mean value. In data with a normal distribution, the mean, median and mode values all coincide. The location parameter represents the mean value and the scale parameter represents the standard deviation of the data. Figure 3 shows the change in the shape of the normal distribution curve as the scale parameter increases. The width of the normal distribution curve increases with an increase in the standard deviation.

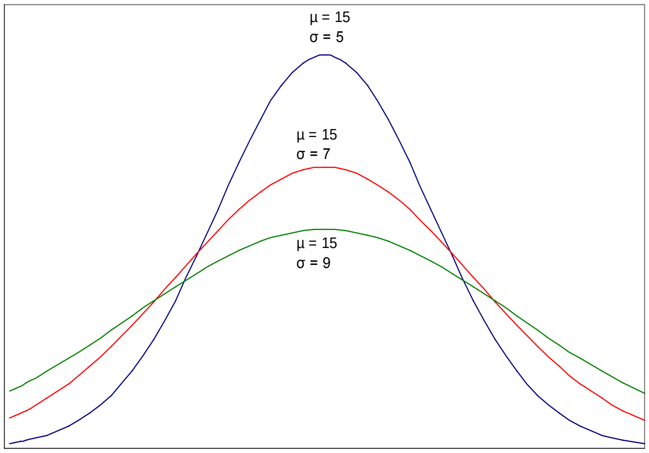

Figure 3. Effect of Parameter Changes on the Normal Distribution Curve.

Weibull Probability Distribution:

$$f(x) = \frac{\beta}{\alpha^{\beta}}(x-\theta)^{\beta-1}e^{\left(-\left(\frac{x-\theta}{\alpha}\right)^{\beta}\right)} \quad \text{(Equation 2)}$$

The Weibull probability distribution represents random data that is left-skewed. The weibull distribution is useful in cases where there are multiple values in the random data distinctly lower than the mean value. Figure 4 shows the change in the shape of the weibull distribution curve to become more left-skewed as the shape parameter increases.

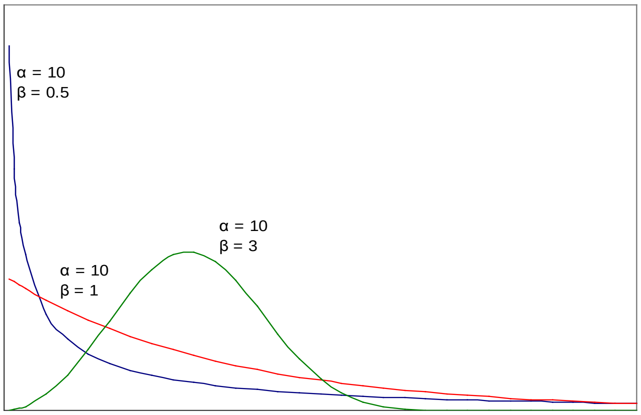

Figure 4. Effect of Parameter Changes on the Weibull Distribution Curve.

Lognormal Probability Distribution:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}\,(x-\theta)} e^{\left(-\frac{(\ln(x-\theta)-\mu)^2}{2\sigma^2}\right)} \quad \text{(Equation 3)}$$

The Lognormal probability distribution represents random data that is right-skewed. The lognormal distribution is useful in cases where there are multiple values in the random data distinctly higher than the mean value. Figure 5 shows the effect of changing the location and scale parameters on the shape of the lognormal distribution curve. The skewness of the distribution curve increases as the location parameter decreases or as the scale parameter increases. Random data is lognormally distributed if the logarithm of the data is normally distributed. Since this is true, the lognormal distribution curve, although right-skewed, maintains relative symmetry about the weight mean.

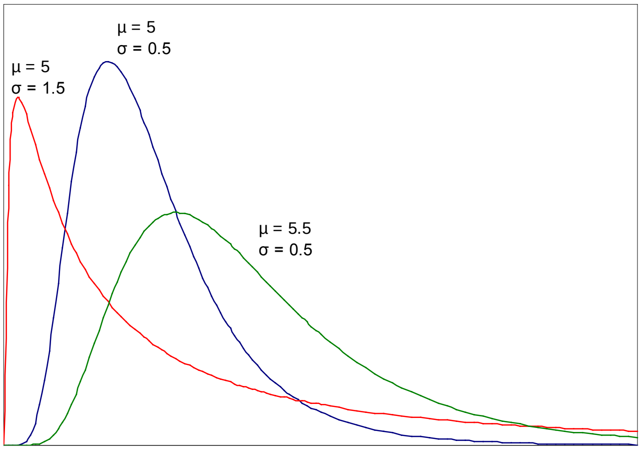

Figure 5. Effect of Parameter Changes on the Lognormal Distribution Curve.

Smallest Extreme Value Probability Distribution:

$$f(x) = \frac{1}{\sigma} e^{\left(\frac{x-\mu}{\sigma}\right)} e^{\left(-e^{\left(\frac{x-\mu}{\sigma}\right)}\right)} \quad \text{(Equation 4)}$$

The Smallest Extreme Value probability distribution represents random data that is sharply left-skewed. The smallest extreme value distribution is useful in cases where the random data has a mean value that is close to the maximum value. The location parameter represents the mean value and the scale parameter represents the standard deviation of the random data. Figure 6 shows the effects on the smallest extreme value distribution curve due to changes in the location and scale parameters. An increase in the location parameter causes the distribution curve to shift along the x-axis. When the scale parameter is increased, the distribution curve becomes less left-skewed.

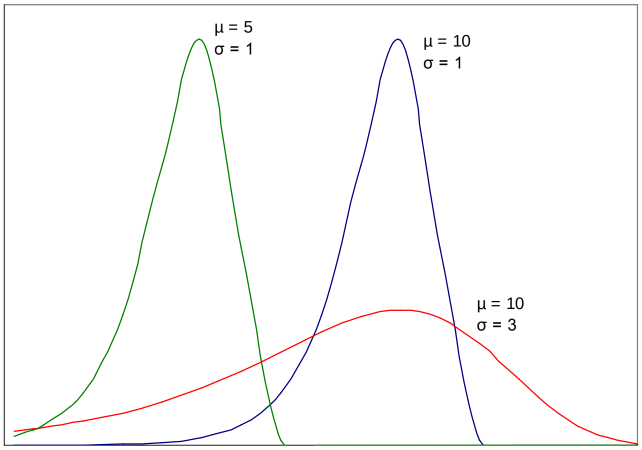

Figure 6. Effect of Parameter Changes on the Smallest Extreme Value Distribution Curve.

Loglogistic Probability Distribution:

$$f(x) = \frac{e^{\left(\frac{\ln(x-\theta)-\mu}{\sigma}\right)}}{(x-\theta)\,\sigma\left[1+e^{\left(\frac{\ln(x-\theta)-\mu}{\sigma}\right)}\right]^2} \qquad \text{(Equation 5)}$$

The Loglogistic probability distribution represents random data that is right-skewed. The loglogistic distribution is useful in cases where the random data contains multiple values higher than the mean value. Figure 7 shows the effects on the loglogistic distribution curve due to changes in the location and scale parameters. The loglogistic distribution curve becomes less skewed as the location parameter increases or as the scale parameter decreases.

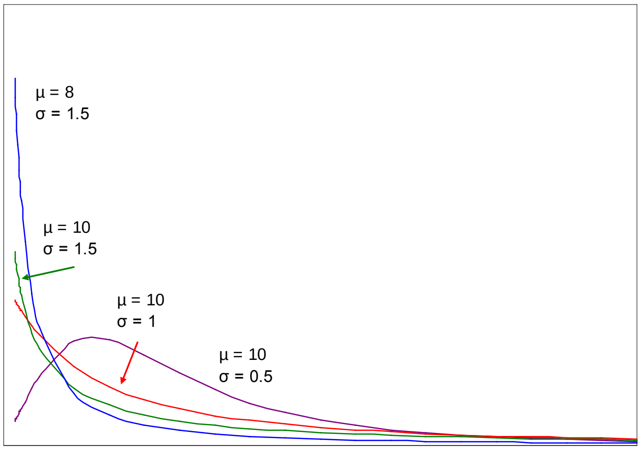

Figure 7. Effect of Parameter Changes on the Loglogistic Distribution Curve.

Overall, the combined volume of fuel received in Region 1 and 4 accounted for less than ten percent of the total volume of fuel procured annually in CONUS. Therefore, data analysis for Regions 2, 3 and 5 are believed to be more indicative of historical trends and those expected in the future. Within the PQIS data, there are a limited number of fuel procurements with recorded property values that fall significantly outside of the normal specification range. Although the specific causes for these discrepancies are unknown, values recorded outside the normal specification range may have been caused by analytical or data recording errors. These anomalies are not necessarily believed to demonstrate the expected property trends for a given region and thus focus should be given to data within the typical specification requirements.

The next six sections contain analyses of the PQIS data for the following JP-8 fuel properties: aromatic content, density, freeze point, viscosity, heat of combustion, and volumetric heating value. The data for each property are analyzed independently as a function of year and region in which the fuel was procured. The data from the individual regions are then combined for all CONUS to determine the statistical variance/trends in the respective properties. Following analysis for each individual property, analysis was performed to determine if correlations exist between the properties, which can allow for subsequent prediction of future property values. Limited data is presented in these sections, but a detailed analysis of each property, the correlation of the distributions with the PQIS data, and the confidence intervals based on the PQIS data and distribution fit can be found for all years studied in Appendix A.

3.1.1. Statistical Analysis for Aromatic Content of JP-8 Fuels

The MIL-DTL-83133F fuel specification requirement allows a total maximum aromatic content of 25.0% by volume with no minimum requirement. The latter is not required as aviation fuels produced from petroleum will always contain a significant aromatic concentration. The following section analyzes the PQIS aromatic content data from Regions 1-5 of CONUS for the years 1997-2008. The complete detailed analysis of the aromatic content, the correlation of the selected distribution with the PQIS data, and the confidence intervals based on the PQIS data and distribution as a function of region and year is included in Appendix A. The calculated weight mean aromatic content and 80% confidence interval are listed for each year in the regions of CONUS within this section. The 80% confidence interval is representative of the variation in volume and/or aromatic content of fuel based on the position of the weight mean within the confidence interval and provides guidance regarding general variability in the data. During analysis, the percent of the total fuel volume within the region for a given year is also plotted as a function of the PQIS aromatic content. The 95% confidence interval is labeled on the figures to demonstrate the range in the value of aromatic content since a large percentage of the data falls within these intervals. The 60% confidence interval shows the focal or center range in which the value of aromatic content is likely to fall. The data from 1999 for Regions 1-5 and from 2008 for CONUS are plotted in these figures since a large volume of fuel was procured during these years and the relative distribution is representative of fuel procured within each specific region over the time period investigated.

3.1.1.1. Region 1

Table 1 shows the calculated weight mean and 80% confidence interval of the aromatic content from the 1997-2005 and 2007-2008 PQIS data for Region 1 of CONUS. No JP-8 fuel was reported as being procured in Region 1 of CONUS in 2006. The weight means of aromatic content are consistently about 16.7 vol. % for 1997-2001 and consistently higher at approximately 20.0 vol. % for 2002-2004. For the years 2005, 2007 and 2008, the weight mean is between these two values at about 18.0 vol. %. The upper bound of the 80% confidence interval is higher in the years 1999 and 2001 due to a number of low volume fuel procurements with high aromatic content. In the years 2002-2005 and 2007, there was only a low volume of fuel procured with an aromatic content of less than 17.0 vol. %, resulting in a higher weight mean and confidence interval than in the previous years. In the years with similar weight means, the confidence intervals were consistent with the exception of the year 2004 and 2008. In 2004, there were a few large volume fuel procurements with lower aromatic content causing the lower bound of the confidence intervals to be reduced. Similarly, in 2008, there was one large volume of fuel procured with a low aromatic content resulting in the reduced lower bound of the confidence intervals. <u>There is a significant increase for the mean aromatic content of fuel procured in the years 1997-2001 (16.7 vol. %) to the fuel procured in 2002-2004 (20.0 vol. %) and then a slight decline in the years 2005 and 2007-2008 (18.0 vol. %)</u>.

Table 1. Aromatic Content Statistics for Region 1.

Year	Wt mean	80% CI
1997	16.4	(14.7, 18.2)
1998	16.6	(15.1, 18.6)
1999	17.3	(14.9, 19.4)
2000	16.7	(15.0, 18.8)
2001	16.7	(14.4, 20.4)
2002	20.8	(19.4, 22.3)
2003	20.6	(18.7, 22.9)
2004	20.6	(17.1, 23.4)
2005	18.8	(17.5, 20.4)
2007	18.4	(17.8, 18.9)
2008	17.7	(12.1, 18.9)

Each individual fuel procurement in Region 1 during 1999 is shown in Figure 8. For each fuel procurement, the aromatic content and corresponding percent of total volume are shown. The weighted aromatic mean was 17.3 vol. % and the 95% and 60% confidence intervals are shown.

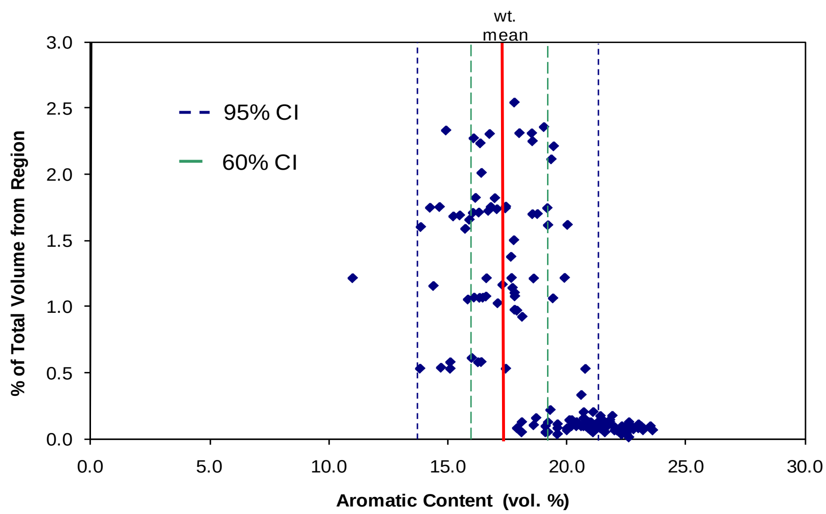

Figure 8. 1999 PQIS Aromatic Content Data for Region 1.

As shown in Figure 8, the aromatic content data is right-skewed. The symmetry of the confidence intervals indicates the data maintains a relatively normal shape. Within each year, there were high volume fuel procurements with low aromatic content and lower volume procurements with high aromatic content. Thus the aromatic content of Region 1 was found to have a lognormal probability distribution for each year from 1997-2008. Figure 9 shows the lognormal fit curves for the years 1997-2008 from Region 1. Since the y-axis is the volume of fuel procured for a specific aromatic content, the variation in the height of the curves is due to the differing volumes of fuel procured each year. The two sets of years with similar weighted mean (1997-2001, 2002-2004, and 2005-2008) have distribution curves with consistent shapes and locations along the x-axis.

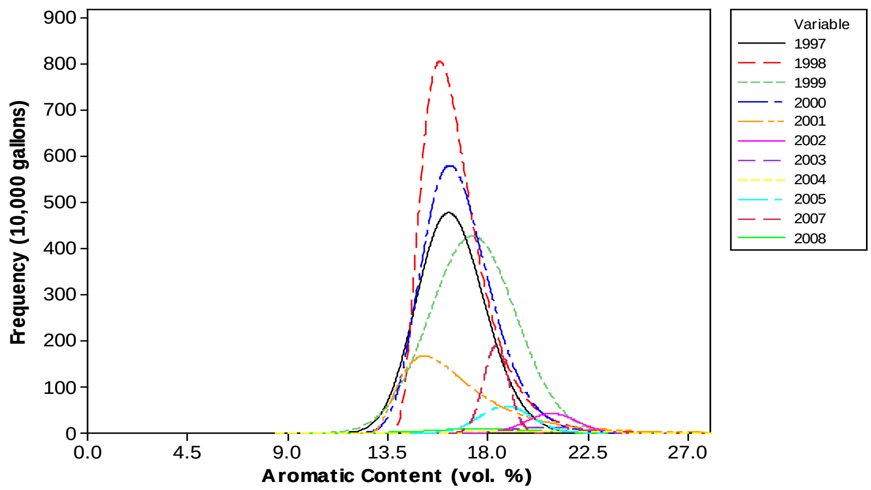

Figure 9. Histogram of the Lognormal Distribution Fit Curves of the PQIS Aromatic Content Data for Region 1 from 1997-2008.

Overall, the fuel procured in Region 1 has shown a distinct shift in the aromatic content from 1997-2001 (16.7 vol. %) to 2002-2004 (20.0 vol. %) and a slight decline in 2005 and 2007-2008 (18.0 vol. %). The relative consistency in the aromatic content over the last six years can allow for the prediction of the aromatic content of fuel procured in Region 1 within a range of 17.0 to 23.0 vol. % and a average mean value of 19.0 vol. %. However, since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of trends for CONUS combined.

3.1.1.2. Region 2

Table 2 shows the calculated weight mean and 80% confidence interval of the aromatic content from the 1997-2008 PQIS data for Region 2 of CONUS. There is a clear consistency in the weight mean of approximately 15.0 vol. % aromatic content throughout all twelve years. In the years 1997, 1998, 2003, and 2004, fuel was procured with a recorded aromatic content below 8.0 vol. %, resulting in the lower bound of the 80% confidence interval. In addition, the upper bound of the 80% confidence intervals for 1998, 1999, 2001 and 2002 are higher than other years due to a large volume of fuel procured with high aromatic content. Throughout all years in Region 2, the fuel was procured with a large range of aromatic content.

Table 2. Aromatic Content Statistics for Region 2.

Year	Wt mean	80% CI
1997	14.4	(12.5, 16.3)
1998	14.8	(11.7, 20.3)
1999	15.3	(13.8, 19.8)
2000	15.0	(13.5, 16.0)
2001	15.6	(13.1, 19.1)
2002	15.3	(13.3, 18.2)
2003	14.8	(13.2, 16.9)
2004	14.7	(12.3, 17.0)
2005	14.6	(12.9, 16.2)
2006	14.6	(13.3, 16.4)
2007	15.0	(12.5, 17.1)
2008	14.9	(13.0, 17.2)

As expected from the range in aromatic content of fuel procured in Region 2, there is a high variability in the 95% and 90% confidence intervals throughout the years. The lower bounds of the confidence intervals are distinctly lower for the years in which fuel was procured with aromatic content below 8.0 vol. %. The 60-80% confidence intervals are consistent for all twelve years since the bulk of the fuel procured in Region 2 has an aromatic content within the same range in each year. Figure 10 shows each individual fuel procurement in Region 2 based on the data from 1999. For each fuel procurement, the aromatic content and corresponding percent of total volume from Region 2 are shown. The weighted aromatic mean is 15.3 vol. % and the 95% and 60% confidence intervals are shown.

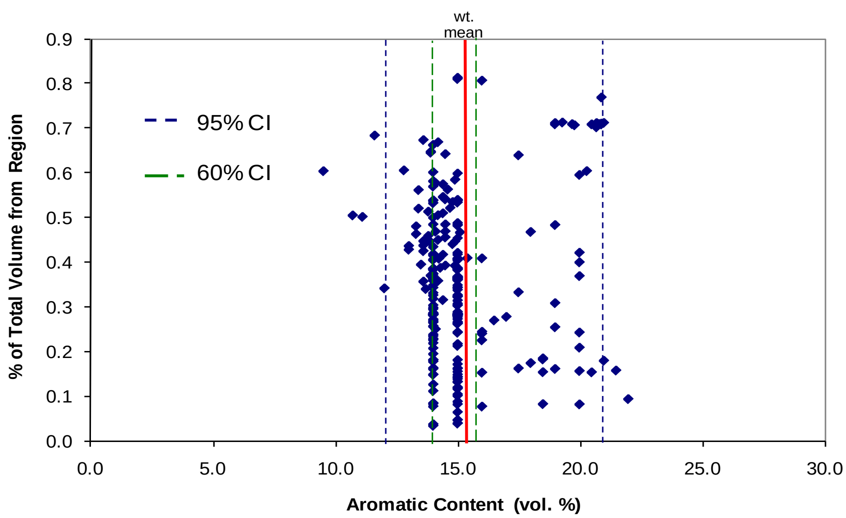

Figure 10. 1999 PQIS Aromatic Content Data for Region 2.

As shown in Figure 10, there are large volume procurements with higher aromatic content than the weighted mean causing a varied 95% confidence interval. The position of the 95% confidence interval shows the data is right-skewed. However, based on the position of the 60% confidence interval the data appears left-skewed. This discrepancy is due to the large volume of fuel procured with an aromatic content close to the mean value and a few high volume fuel procurements with high aromatic content, causing a shift in the lower confidence intervals.

Due to the procurement of more fuel with lower aromatic content and only a few high volume procurements of fuel with high aromatic content, the right-skewed form of the loglogistic distribution fits the data for Region 2. Figure 11 shows the loglogistic fit curves for the years 1997-2008 from Region 2. The distribution curves for all twelve years in Region 2 have consistent shapes. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

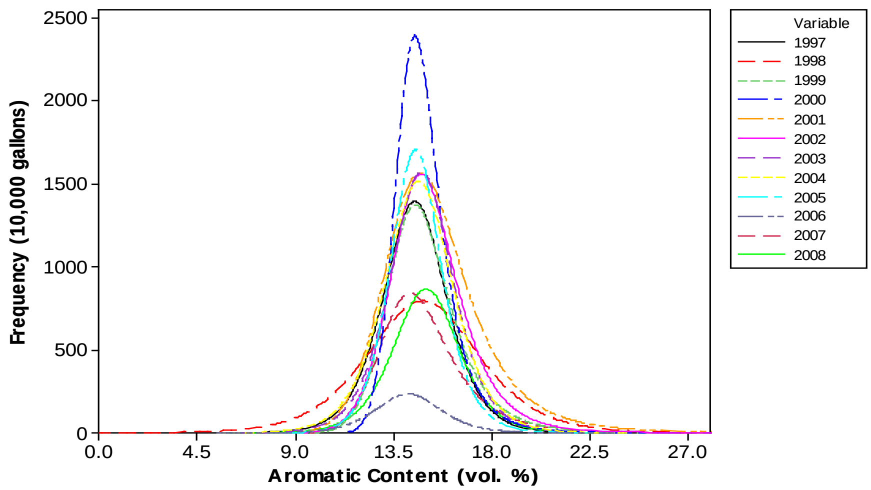

Figure 11. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Aromatic Content Data for Region 2 from 1997-2008.

Due to the fit of the function, the distributions in Figure 11 show some years to have fuel with lower and/or higher aromatic content than was actually procured during those years. The procurement of fuel with very low and/or high aromatic content was inconsistent in throughout all years. *Overall, the aromatic content of fuel procured in Region 2 has been consistent within a range of 12.0 to 20.0 vol. % with a mean value of 15.0 vol. % throughout the years 1997-2008.*

3.1.1.3. Region 3

Table 3 shows the calculated weight mean and 80% confidence interval of the aromatic content from the 1997-2008 PQIS data for Region 3 of CONUS. With the exception of 1999 and 2002, all years have a consistent weight mean of approximately 19.0 vol. % aromatic content due to a consistently large volume of fuel procured with high aromatic content during these years. The weight mean for 1999 was slightly lower at 18.0 vol. % due to small volumes of fuel procured with low aromatic content and few fuel procurements with high aromatic content during the year. The procurement of large volumes of fuel with higher aromatic content in 2002 caused the weight mean of aromatic content to be 20.2 vol. %. The 80% confidence intervals are all within a consistent aromatic range of 14.0 to 23.0 vol. % and thus the aromatic content of fuel procured in Region 3 can statistically be expected to fall within this range.

Table 3. Aromatic Content Statistics for Region 3.

Year	Wt mean	80% CI
1997	18.9	(14.0, 23.6)
1998	18.8	(14.4, 22.9)
1999	18.0	(14.7, 20.6)
2000	19.3	(15.8, 22.1)
2001	19.5	(15.6, 23.0)
2002	20.2	(15.6, 23.5)
2003	19.3	(15.2, 22.8)
2004	18.8	(14.8, 22.6)
2005	18.9	(15.1, 22.3)
2006	18.5	(13.9, 22.7)
2007	18.6	(14.6, 22.4)
2008	18.5	(14.8, 22.2)

In Region 3, the confidence intervals for 1997-1999, 2006, and 2008 are slightly varied from other years. A low volume of fuel procured in these years had a low aromatic content resulting in a reduction of the lower bounds of the confidence intervals. Also in 1999, the upper bounds of the confidence intervals are lower due to the procurement of a lower volume of fuel with high aromatic content than other years. Figure 12 shows each individual fuel procurement in Region 3 based on the data from 1999. For each fuel procurement, the aromatic content and corresponding percent of total volume are shown. The weighted aromatic mean is 18.0 vol. % and the 95% and 60% confidence intervals are shown. Figure 12 demonstrates the large number of fuel procurements and the range of aromatic content of the fuel.

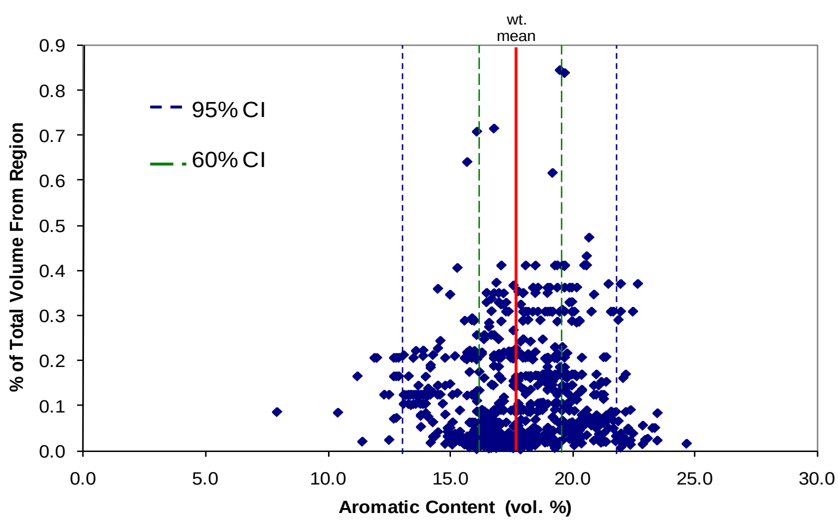

Figure 12. 1999 PQIS Aromatic Content Data for Region 3.

As shown in Figure 12, the position of the 95% confidence interval shows the data is left-skewed. Due to a number of low volume fuel procurements with low aromatic content and the large volume of fuel procured with high aromatic content, the left-skewed form of the weibull distribution fits the data for Region 3. Figure 13 shows the weibull fit curves for the years 1997-2008 from Region 3. The distribution curves for all twelve years in Region 3 have consistent shapes. The curves are slightly shifted for some years due to differences in the mean values.

The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

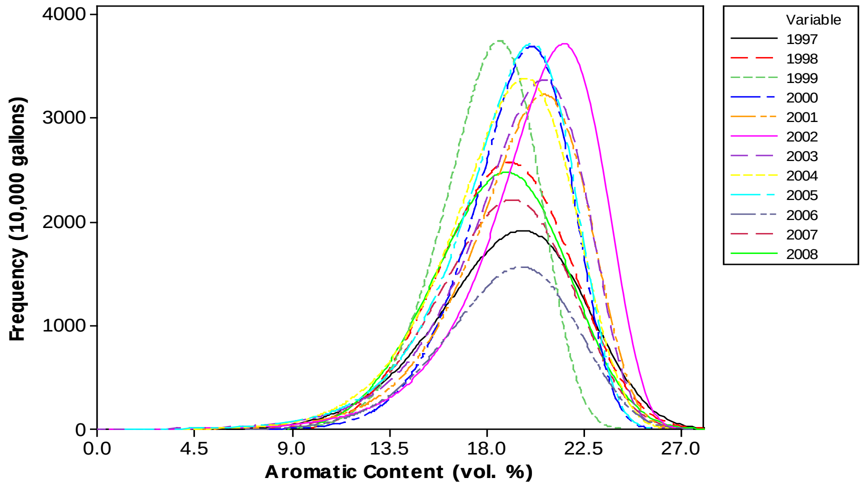

Figure 13. Histogram of the Weibull Distribution Fit Curves of the PQIS Aromatic Content Data for Region 3 from 1997-2008.

The aromatic content data is consistently left-skewed throughout the years 1997-2008. Some variation exists in the number and volume of fuel procurements with high aromatic content causing slight differences in the skewness and position of the fit curves on the x-axis, as shown in Figure 13. *In general, the aromatic content of fuel procured in Region 3 has been consistent within a range of 14.0 to 23.0 vol. % with a mean value of approximately 19.0 vol. % throughout the years 1997-2008.*

3.1.1.4. Region 4

Table 4 shows the calculated weight mean and 80% confidence interval of the aromatic content from the 1997-2008 PQIS data for Region 4 of CONUS. There is a slight variation in the weight mean throughout all years ranging from 15.3 to 17.8 vol. % aromatic content, being slightly lower in 1997-2001 and 2008 than in 2002-2007. The mean is consistently about 16.0 vol. % for the years 1997-2001 and 2008 with an increase to approximately 17.0 vol. % for the years 2002-2007. In Region 4, there are a low number of fuel procurements. The few fuel procurements in each year of Region 4 have considerable variation in aromatic content ranging from 11.0 to 23.0 vol. %. This variation causes the inconsistency in weighted means and 80% confidence intervals throughout the years.

Table 4. Aromatic Content Statistics for Region 4.

Year	Wt mean	80% CI
1997	15.9	(13.8, 17.8)
1998	15.8	(13.5, 19.0)
1999	16.2	(12.9, 19.9)
2000	15.3	(12.1, 20.7)
2001	16.1	(12.2, 21.7)
2002	17.8	(14.0, 22.2)
2003	16.9	(14.8, 21.1)
2004	17.1	(14.7, 20.6)
2005	16.4	(13.0, 21.7)
2006	16.7	(13.5, 21.7)
2007	17.3	(13.5, 21.3)
2008	15.8	(12.7, 20.9)

Due to the variation in the aromatic content of fuel procured in Region 4, the confidence intervals are inconsistent throughout most of the years. Figure 14 shows each individual fuel procurement in Region 4 based on the data from 1999. For each fuel procurement, the aromatic content and corresponding percent of total volume from Region 4 are shown. The weighted aromatic mean is 16.2 vol. % and the 95% and 60% confidence intervals are shown. The low number of fuel procurements and variation in aromatic content can be readily observed.

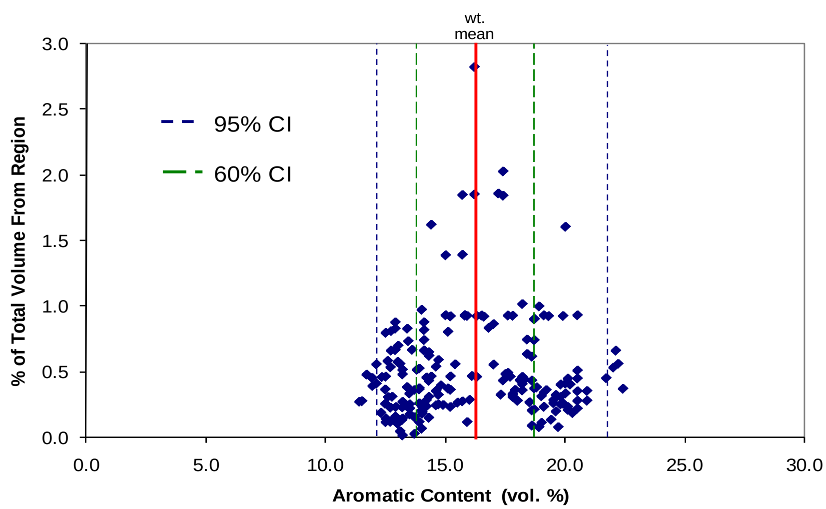

Figure 14. 1999 PQIS Aromatic Content Data for Region 4.

As shown by the position of the 95% confidence interval in Figure 14, the aromatic content data is right-skewed. Due to a low volume of fuel procured with high aromatic content, the right-skewed form of the lognormal distribution fits the data for Region 4. Figure 15 shows the lognormal fit curves for the years 1997-2008 from Region 4. The distribution curves for all twelve years in Region 4 have consistent shapes. However, the curves are shifted for some years due to differences in the mean values and slightly wider due to differences in the range of aromatic content.

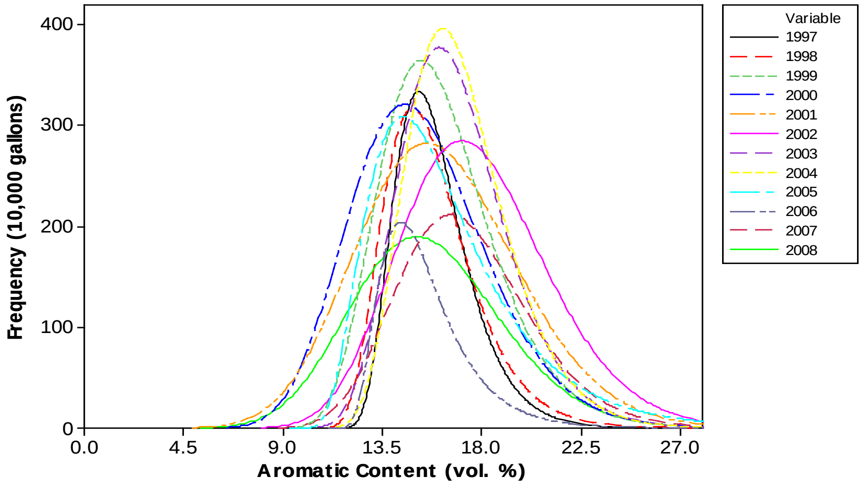

Figure 15. Histogram of the Lognormal Distribution Fit Curves of the PQIS Aromatic Content Data for Region 4 from 1997-2008.

Due to the fit of the function, the curve fits in Figure 15 show some years to have procured fuel with lower and/or higher aromatic content than was actually procured during those years. The procurement and volume of fuel with very low and/or high aromatic content was inconsistent in the years 1997-2008. *The range in aromatic content, as well as the volume of each fuel procurement in Region 4, is drastically different throughout the years 1997-2008. Therefore, the aromatic content of fuel procured in Region 4 cannot be predicted with a high degree of certainty.* Since the fuel procured in Region 4 accounts for less than five percent of the annual total fuel procured within CONUS, Region 4 will most likely not be indicative of trends for CONUS combined.

3.1.1.5. Region 5

Table 5 shows the calculated weight mean and 80% confidence interval of the aromatic content from the 1997-2008 PQIS data for Region 5 of CONUS. With the exception of the years 2001, 2002, 2004 and 2005, the weight mean of the aromatic content is consistently about 18.0 vol. % throughout the years. These years have a slightly lower mean aromatic content of 16.7 vol. % due to a high volume of fuel with lower aromatic content. The lower bounds of the 80% confidence intervals are inconsistent throughout all years in Region 5. This inconsistency is due to the variation in the volume of fuel procured with low aromatic content in each year. The volume of fuel with low and high aromatic content is evenly balanced causing the similar weight means and varied confidence intervals throughout all years.

Table 5. Aromatic Content Statistics for Region 5.

Year	Wt mean	80% CI
1997	17.8	(12.5, 21.5)
1998	17.7	(13.2, 21.4)
1999	18.2	(14.1, 20.6)
2000	17.6	(13.6, 20.3)
2001	16.8	(11.5, 20.0)
2002	16.7	(10.5, 19.9)
2003	17.6	(11.4, 20.9)
2004	16.7	(13.6, 20.4)
2005	16.2	(11.0, 19.2)
2006	18.4	(16.1, 20.1)
2007	18.1	(16.7, 19.3)
2008	18.7	(15.3, 21.0)

Although the weighted means throughout all years in Region 5 are relatively consistent, there is variability in the confidence intervals. In years where fuel was procured with aromatic content below the normal specification limits, the lower bounds of the confidence intervals are reduced to include the fuels with low aromatic content. The variation in the volume of the fuel procurements and aromatic content causes differences in the confidence intervals, which become balanced when calculating the average. This results in the similar weight means shown in Table 5. Figure 16 shows each individual fuel procurement in Region 5 based on the data from 1999. For each fuel procurement, the aromatic content and corresponding percent of total volume from Region 5 are shown. The weighted aromatic mean is 18.2 vol. % and the 95% and 60% confidence intervals are shown. The even dispersal of the volume of the fuel procurements and the aromatic content can be seen in Figure 16.

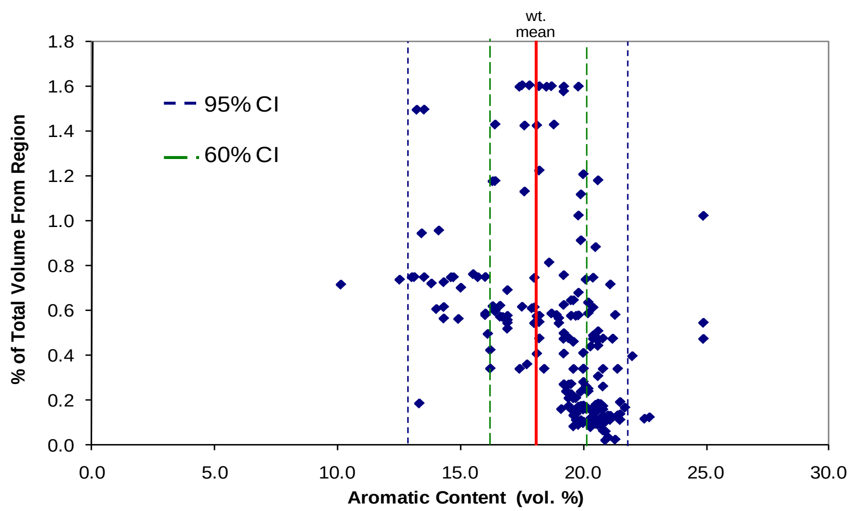

Figure 16. 1999 PQIS Aromatic Content Data for Region 5.

As shown in Figure 16 by the position of the 95% confidence interval, the aromatic content data is left-skewed. Due to a few larger volume procurements with low aromatic content, the left-skewed form of the weibull distribution fits the data for Region 5. Figure 17 shows the weibull fit curves for the years 1997-2008 from Region 5. The distribution curves for all twelve years in Region 5 have consistent shapes. The curves are slightly shifted for some years due to small differences in the mean values.

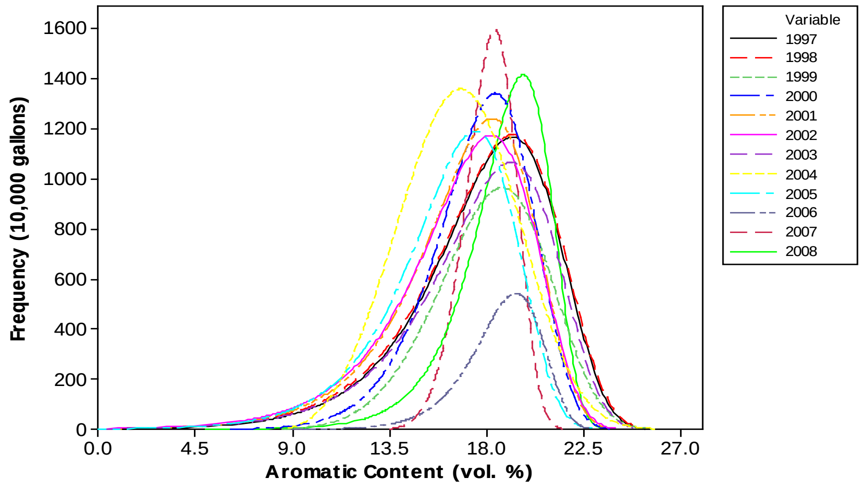

Figure 17. Histogram of the Weibull Distribution Fit Curves of the PQIS Aromatic Content Data for Region 5 from 1997-2008.

The aromatic content data is consistently left-skewed throughout the years 1997-2008. Due to the fit of the distribution, the curve fits in Figure 17 show some years to have procured fuel with lower and/or higher aromatic content than was actually procured during those years. Some variation exists in the number and volume of fuel procurements with low and/or high aromatic content causing inconsistencies in the confidence intervals. *In general, the aromatic content of fuel procured in Region 5 has been consistent within a range of 13.0 to 21.0 vol. % with a mean value of about 18.0 vol. % throughout the years 1997-2008.*

3.1.1.6. CONUS

Table 6 shows the calculated weight mean and 80% confidence interval of the aromatic content from the 1997-2008 PQIS data for Regions 1-5 of CONUS combined. The weight mean of aromatic content is consistently about 18.0 vol. % throughout the years with the exception of 2002 being slightly greater at 18.7 vol. %. The lower bounds in the 80% confidence intervals are consistent for all twelve years. There is a slight variation in the upper bounds of the confidence intervals due to differences in the volume of fuels with high aromatic content procured in each year. The volume of fuel with low and high aromatic content is evenly balanced causing the similar weight means and consistent 80% confidence intervals throughout all years.

Table 6. Aromatic Content Statistics for CONUS.

Year	Wt mean	80% CI
1997	17.7	(13.4, 22.5)
1998	17.8	(13.9, 22.1)
1999	17.5	(14.0, 20.5)
2000	18.0	(13.9, 21.5)
2001	18.0	(13.4, 22.6)
2002	18.7	(13.7, 23.0)
2003	18.2	(13.8, 22.3)
2004	17.7	(13.9, 21.8)
2005	17.7	(13.6, 21.8)
2006	17.9	(14.0, 22.3)
2007	18.0	(14.1, 22.0)
2008	18.1	(14.3, 21.8)

Since the weighted means are consistent throughout all years in CONUS, the confidence intervals are fairly consistent. Figure 18 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the aromatic content and corresponding percent of total volume from CONUS are shown. The weighted aromatic mean is 18.1 vol. % and the 95% and 60% confidence intervals are shown. Figure 18 shows the low volume fuel procurements with lower and higher aromatic content than the weight mean.

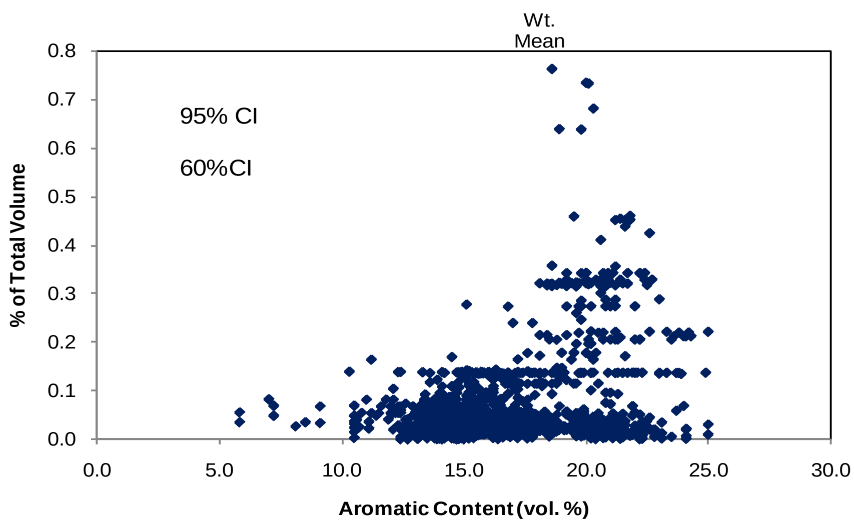

Figure 18. 2008 PQIS Aromatic Content Data for Regions 1-5.

As shown in Figure 18, the aromatic content data is slightly left-skewed. The appearance of an almost normal distribution is caused by the large number of fuel procurements with aromatic content within a consistent range. Due to a few number of small fuel procurements with low aromatic content and larger procurements of high aromatic content, the left-skewed form of the weibull distribution fits the data for CONUS. Figure 19 shows the weibull fit curves for the years 1997-2008 from CONUS. The distribution curves for all twelve years in CONUS have consistent shapes and positions. The volume of fuel procured from Regions 3 and 5, which both have a weibull probability distribution, together account for almost eighty percent of the total fuel procured annually within CONUS. Thus it is not surprising that the data for all of CONUS combined also has a weibull probability distribution.

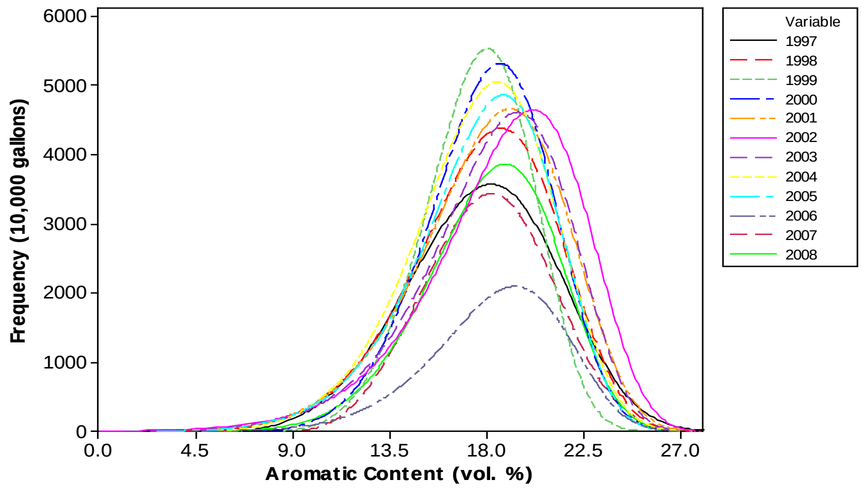

Figure 19. Histogram of the Weibull Distribution Fit Curves of the PQIS Aromatic Content Data for CONUS from 1997-2008.

The aromatic content data for CONUS combined is consistently left-skewed. Throughout the years 1997-2008, there have consistently been fuel quantities procured in small volumes which have low aromatic content and large volumes which have an aromatic content ranging from 18.0 to 22.0 vol. %. *In general, the aromatic content of fuel procured in CONUS has been consistent within a range of 13.0 to 22.0 vol. % with a mean value of approximately 18.0 vol. % throughout the years 1997-2008.* The range of aromatic content of fuel procured in CONUS is consistent with the range for each individual region. <u>However, the mean value of aromatic content for CONUS is the average of the weighted means from each individual region and thus is not consistent for each individual region.</u>

3.1.1.7. Variability of Aromatic Content as a Function of Region

Table 7 shows the calculated weight mean and 80% confidence interval of the aromatic content from the PQIS data for Regions 1-5 of CONUS from the combined years 1997-2008. There is a statistical difference in the weight mean between the five regions and all of CONUS. The fuel procured in Region 3 had higher aromatic content than any other region, resulting in the highest weight mean. The weight mean for CONUS combined is higher than the weight mean of Regions 2, 4, and 5 due to the high volume of fuel procured in Region 3 with high aromatic content. The 80% confidence intervals are inconsistent for all regions and CONUS due to variations in the range of aromatic content and volume of fuel procured in each region. The overlap in the confidence intervals is representative of the range of aromatic content for each region. *However, the differences in the upper and lower bounds of the confidence intervals are too significant to disregard. Thus the range in aromatic content of fuel procured within each region may need to be considered separately*. Figure 20 shows the weight mean aromatic content as a function of years from 1997-2008 for Regions 1-5 of CONUS. The fuel procured in Region 2 has consistently the lowest mean aromatic content of all regions with the least variation throughout all years.

Table 7. Aromatic Content Statistics for All Years.

Region	Wt. Mean	80% CI
1	16.9	(15.0, 19.3)
2	14.9	(13.0, 17.4)
3	18.9	(14.8, 22.9)
4	16.5	(13.2, 21.3)
5	17.5	(13.3, 20.7)
CONUS	18.0	(14.0, 22.2)

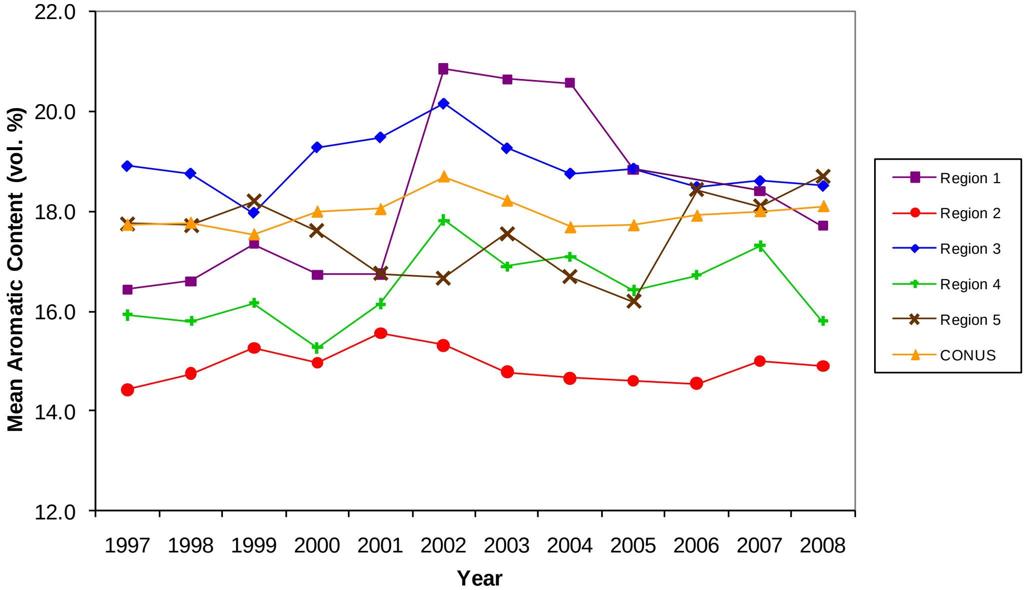

Figure 20. Weight Mean Aromatic Content from Years 1997-2008 as a Function of Region and CONUS.

Figure 21 shows each individual fuel procurement for the regions based on the combined data from 1997-2008. For each fuel procurement, the aromatic content and corresponding percent of total volume from each region are shown. The fuel procured in each region has a wide range of aromatic content. As shown in Figure 21, there is no consistent distribution of data between all five regions. With such statistical differences between the aromatic content of the fuel between most of the regions, the regions may need to be considered independently when analyzing property distributions and variance over time. If all regions of CONUS were considered concurrently, the aromatic content of a portion of the fuel procured in Regions 1, 2 and 4 will be largely overestimated resulting in inaccurate prediction of aromatic content.

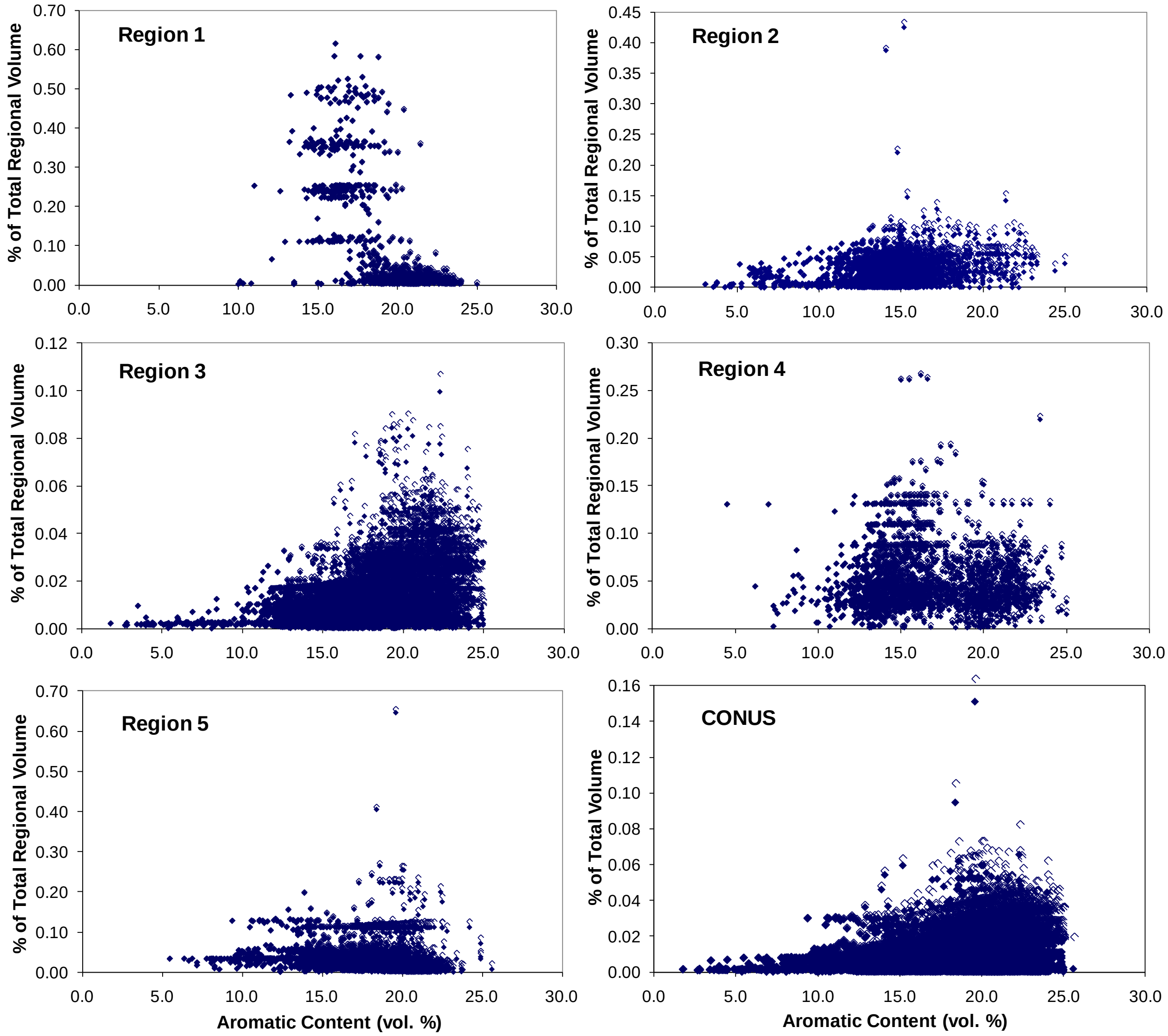

Figure 21. Combined PQIS Aromatic Content Values from 1997-2008 as a Function of Region.

3.1.1.8. Summary of Aromatic Content Analysis

Based on the historical aromatic content data from Regions 1 and 4, there is no consistency in the aromatic content of fuel procured throughout all years. In Region 1, there is a distinct shift in the aromatic content of fuel procured in the years 1997-2001 (16.7 vol. %) from the fuel procured in 2002-2004 (20.0 vol. %) and then a slight decline in 2005 and 2007-2008 (18.0 vol. %). The relative consistency in the aromatic content over the last six years can allow for the prediction of the aromatic content of fuel procured in Region 1 within a range of 17.0 to 23.0 vol. % and a mean value of 19.0 vol. %. The range in aromatic content as well as the volume of each fuel procurement in Region 4 is drastically different throughout the years 1997-2008. Therefore, the aromatic content of fuel procured in Region 4 cannot be predicted with a high degree of certainty. Since the fuel procured in Regions 1 and 4 accounts for less than ten percent of the total fuel procured annually within CONUS, Regions 1 and 4 are not indicative of cumulative trends.

In Regions 2, 3 and 5, there are trends in the historical aromatic content data that can be useful in predicting aromatic content of fuels from these regions. The aromatic content of fuel procured in Region 2 has been consistent within a range of 12.0 to 20.0 vol. % with a mean value of 15.0 vol. %. Due to the procurement of large volumes of fuel with lower aromatic content and only a few high volume procurements with high aromatic content, the right-skewed form of the loglogistic distribution fits the aromatic content data for Region 2. The aromatic content of fuel procured in Region 3 has been consistent within a range of 14.0 to 23.0 vol. % with a mean value of approximately 19.0 vol. %. The left-skewed form of the weibull distribution fits the aromatic content data for Region 3 because of a number of low volume fuel procurements with low aromatic content and a large volume of fuel procured with high aromatic content in Region 3. The aromatic content of fuel procured in Region 5 has been consistent within a range of 13.0 to 21.0 vol. % with a mean value of approximately 18.0 vol. %. Due to a small number of large procurements with low aromatic content, the left-skewed form of the weibull distribution fits the data for Region 5.

From the analysis of the aromatic content of each region throughout the years 1997-2008, it is apparent that consistent trends exist within Regions 2, 3 and 5 and Regions 1-5 combined. The aromatic content of fuel procured in Regions 1 and 4 are not consistent. The aromatic content of fuel procured in CONUS has been consistent within a range of 13.0 to 22.0 vol. % with a mean value about 18.0 vol. %. The data for CONUS is left-skewed because of a number of small fuel procurements with low aromatic content and larger procurements of high aromatic content. Although the combined analysis of CONUS was consistent, the difference between regions is too substantial to disregard and allow for the combined analysis of all regions. A summary of the trends in aromatic content mean statistics and 60% and 80% confidence intervals for each region and CONUS combined is shown in Table 8. With the exception of Region 4, the aromatic content of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 8.

Table 8. Overall Aromatic Content Statistics for Each Region and CONUS Based on the PQIS Data from 1997-2008.

Region	Mean	60% CI	80% CI
1	19.0*	18.0 - 21.0	**
2	15.0	13.4 - 16.8	12.5 – 17.0
3	19.0	16.0 - 22.0	14.5 – 22.5
4	**	14.0 – 20.0*	13.5 – 21.0*
5	18.0	15.0 - 20.0	**
CONUS	18.0	15.0 - 20.5	14.0 – 22.0

* Consistent over last few years, allowing for future predictions

** Not consistent for consecutive years, cannot be predicted

Overall, based on the analysis of the aromatic content of fuel procured in individual Regions 1-5 and CONUS combined, there are statistical differences in the volume of fuel procured with varying ranges of aromatic content for each region. This is not evident when only reviewing the historical trends for CONUS, and it is apparent that significant over-/underestimations of expected aromatic content could occur if the expected properties are based solely on CONUS. The cause of the significant variations in the average aromatic

content and distribution are not readily known, but could be related to the properties of the petroleum/crude oil and/or refining conditions employed in the respective regions. The prediction of the aromatic content solely based on the analysis of CONUS combined would produce a statistically inaccurate estimation of aromatic content. Therefore, the predictability of the aromatic content is dependent on the region of CONUS in which the JP-8 is procured.

3.1.2. Statistical Analysis for Density of JP-8 Fuels

The MIL-DTL-83133F fuel specification requires JP-8 to have a density within the range of 0.775 – 0.840 g/mL. The following section analyzes the PQIS density data from Regions 1-5 of CONUS for the years 1999-2008. The complete detailed analysis of the density, the correlation of the distribution with the PQIS data, and the confidence intervals based on the PQIS data and distribution as a function of region and year is included in Appendix A. The weight mean density and 80% confidence interval are listed for each year in the regions of CONUS within this discussion. The 80% confidence interval is representative of the variation in volume and/or the density of fuel based on the position of the weight mean within the confidence interval and provides guidance regarding general variability in the data. During analysis, the percent of the total volume of fuel procured within the region for a given year is also plotted as a function of the PQIS density of the fuel. The 95% confidence interval is labeled on the figures to demonstrate the range in the value of the density since a large percentage of the data falls within these intervals. The 60% confidence interval shows the focal or center range in which the value of the density is likely to fall. The data from 2001 for Regions 1-5 and from 2008 for CONUS is plotted in these figures since a large volume of fuel was procured during these years and the relative distribution is representative of fuel procured within a specific region.

3.1.2.1. Region 1

Table 9 shows the calculated weight mean and 80% confidence interval of the density from the 1999-2005 and 2007-2008 PQIS data for Region 1 of CONUS. No JP-8 fuel was reported as being procured in Region 1 of CONUS in 2006. The weight mean density is consistently about 0.800 g/mL for 1999-2001, 2005, and 2007-2008, and consistently higher at approximately 0.817 g/mL for 2002-2004. In the years 2002-2004, a larger volume of fuel was procured with a high density than in the previous years, resulting in the higher weight means. The 80% confidence intervals are consistent for most years that have consistent weight means (1999-2001, 2005, and 2007-2008 and 2002-2004). The lower bound of the 80% confidence interval in 2004 was lower than in 2002 and 2003 due to a number of low density fuel procurements in that year. In 2005 and 2007-2008, there were a few high volume fuel procurements with low density resulting in the upper bound of the 80% confidence interval to be lower than in 1999-2001.

Table 9. Density Statistics for Region 1.

Year	Wt mean	80% CI
1999	0.802	(0.795, 0.809)
2000	0.804	(0.798, 0.811)
2001	0.807	(0.800, 0.817)
2002	0.816	(0.811, 0.820)
2003	0.817	(0.812, 0.823)
2004	0.817	(0.804, 0.827)
2005	0.795	(0.793, 0.795)
2007	0.794	(0.792, 0.796)
2008	0.794	(0.793, 0.794)

In the years with similar weight means, the confidence intervals were consistent with the exception of the year 2004. In 2004 there were a few high volume fuel procurements with lower density causing the lower bounds of the confidence intervals to be reduced. Figure 22 shows each individual fuel procurement in Region 1 based on the data from 2001. For each fuel procurement, the density and corresponding percent of total volume from Region 1 are shown. The weighted mean density was 0.807 g/mL and the 95% and 60% confidence intervals are shown.

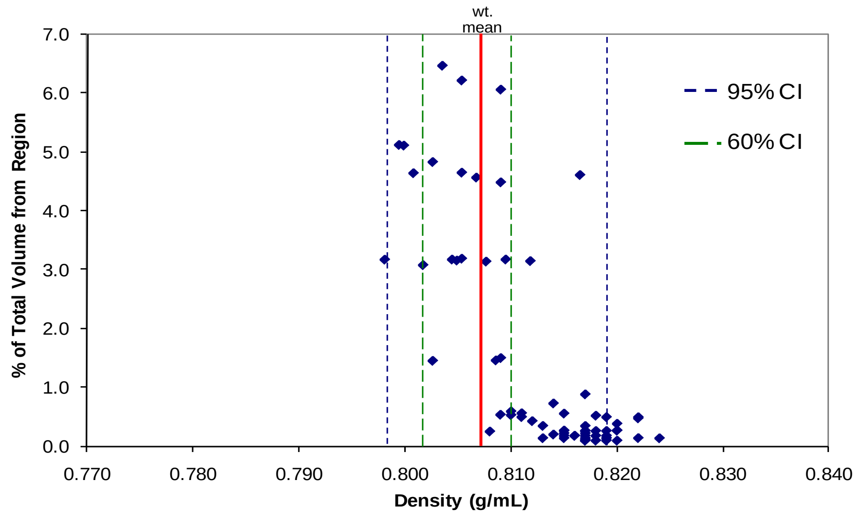

Figure 22. 2001 PQIS Density Data for Region 1.

As shown in Figure 22 by the position of the 95% confidence interval, the density data is right-skewed. The symmetry of the 60% confidence interval indicates the data maintains a relatively normal shape. Due to the high volume fuel procurements of low density and low volume procurements of higher density within each year, the right-skewed form of the lognormal probability distribution fits the data for Region 1. Figure 23 shows the lognormal distribution curves for the years 1999-2007 from Region 1. Due to the low volume of fuel procured in 2008, the distribution curve could not be plotted for this year. Since the y-axis is the volume of fuel procured for a specific density, the variation in the height of the curves is due to the differing volumes of fuel procured. The two sets of years with similar weighted mean (1999-2001 and 2002-2004) have distribution curves with consistent shapes and locations along the x-axis.

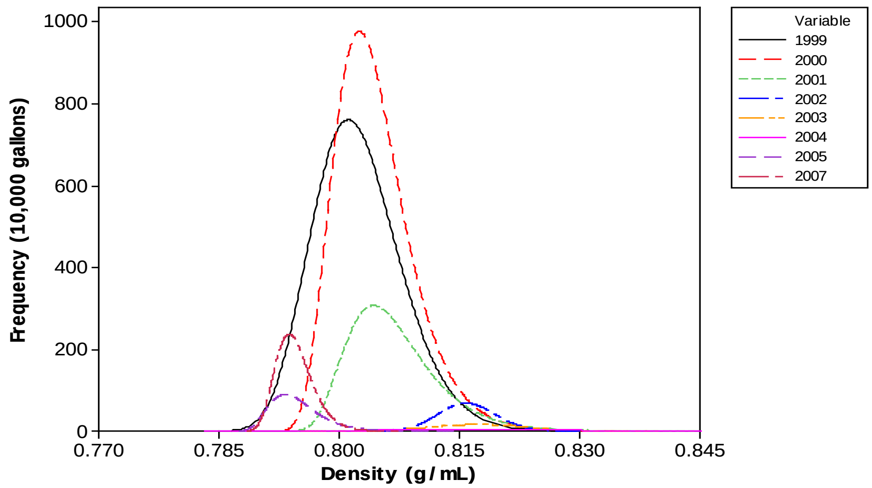

Figure 23. Histogram of the Lognormal Distribution Fit Curves of the PQIS Density Data for Region 1 from 1999-2007.

There is a distinct increase in the density of fuel procured in the years 1999-2001, 2005 and 2007-2008 (0.800 g/mL) to the fuel procured in 2002-2004 (0.817 g/mL). The density of fuel procured in 2005 and 2007-2008 is slightly lower than in 1999-2001 since there was a lower volume of high density fuel procured. The range in the density, as well as the volume of each fuel purchase in Region 1, is not consistent for more than three consecutive years from 1999-2008. *Therefore, the density of fuel procured in Region 1 cannot be predicted with a high degree of certainty*. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of trends for CONUS combined.

3.1.2.2. Region 2

Table 10 shows the calculated weight mean and 80% confidence interval of the density from the 1999-2008 PQIS data for Region 2 of CONUS. There is a clear consistency in the weight mean density of approximately 0.807 g/mL throughout all ten years, which is consistent with trends in the aromatic content from this region. The 80% confidence intervals are fairly consistent for all years. There is a slight variation in the upper bounds of the confidence intervals due to differing volumes of high density fuel procured within each year.

Table 10. Density Statistics for Region 2.

Year	Wt mean	80% CI
1999	0.808	(0.803, 0.818)
2000	0.806	(0.803, 0.811)
2001	0.807	(0.799, 0.817)
2002	0.807	(0.801, 0.816)
2003	0.807	(0.799, 0.812)
2004	0.808	(0.801, 0.814)
2005	0.806	(0.801, 0.809)
2006	0.806	(0.802, 0.809)
2007	0.804	(0.802, 0.806)
2008	0.805	(0.800, 0.809)

As expected from the consistent mean densities for 1999-2008 in Region 2, the confidence intervals are consistent throughout the years. Figure 24 shows each individual fuel procurement in Region 2 based on the data from 2001. For each fuel procurement, the density and corresponding percent of the total volume from Region 2 are shown. The weighted mean density is 0.807 g/mL and the 95% and 60% confidence intervals are shown.

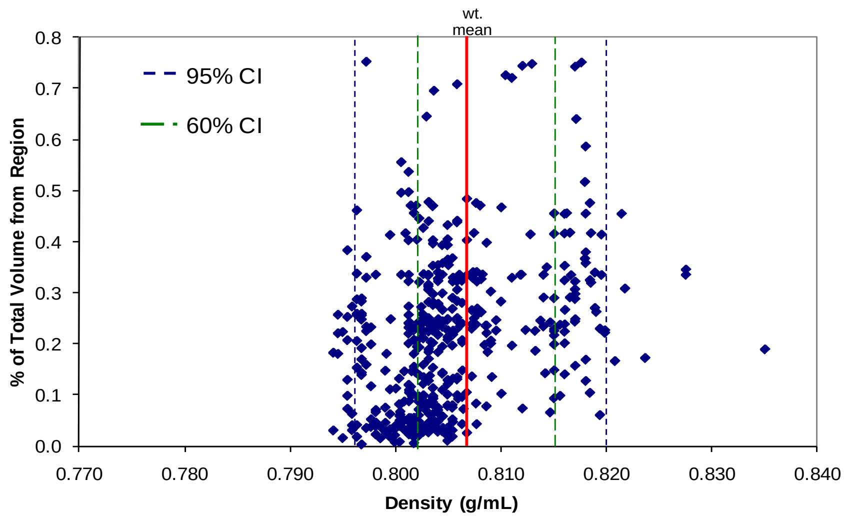

Figure 24. 2001 PQIS Density Data for Region 2.

As shown in Figure 24 by the confidence intervals, the data is right-skewed. Due to the procurement of more fuel with lower density and only a few high volume procurements of fuel with high density, the right-skewed form of the loglogistic distribution fits the data for Region 2. Figure 25 shows the loglogistic distribution curves for the years 1999-2008 from Region 2. The distribution curves for all ten years in Region 2 have consistent shapes. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

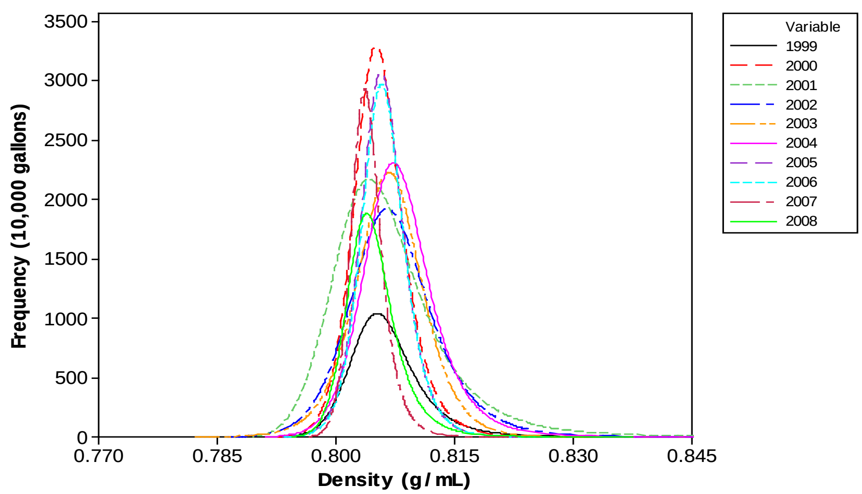

Figure 25. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Density Data for Region 2 from 1999-2008.

The density data is consistently right-skewed throughout the years 1999-2008. Some variation exists in the number and volume of fuel procurements with high density causing slight differences in skewness and position of the distribution curves on the x-axis, as shown in Figure 25. *In general, the density of fuel procured in Region 2 has been consistent within a range of 0.799 to 0.818 g/mL with a mean value of 0.807 g/mL throughout the years 1999-2008.*

3.1.2.3. Region 3

Table 11 shows the calculated weight mean and 80% confidence interval of the density from the 1999-2008 PQIS data for Region 3 of CONUS. All years have a consistent weight mean density of about 0.805 g/mL. Any slight variation in the weight mean is due to the procurement of a larger volume of fuel with either lower or higher density than in other years. The 80% confidence intervals are all within a consistent range since the density of a bulk of the fuel procured in each year falls within the same range.

Table 11. Density Statistics for Region 3.

Year	Wt mean	80% CI
1999	0.803	(0.794, 0.813)
2000	0.804	(0.795, 0.815)
2001	0.805	(0.792, 0.813)
2002	0.807	(0.794, 0.815)
2003	0.806	(0.794, 0.814)
2004	0.801	(0.791, 0.813)
2005	0.803	(0.792, 0.812)
2006	0.805	(0.793, 0.813)
2007	0.804	(0.792, 0.811)
2008	0.803	(0.793, 0.810)

In Region 3, the confidence intervals are comparatively consistent for all ten years. Figure 26 shows each individual fuel procurement in Region 3 based on the data from 2001. For each fuel procurement, the density and corresponding percent of total volume from Region 3 are shown. The weighted mean density is 0.805 g/mL and the 95% and 60% confidence intervals are shown. Figure 26 shows the few large volume procurements with low or high densities that cause the slight variation in weighted mean between the years.

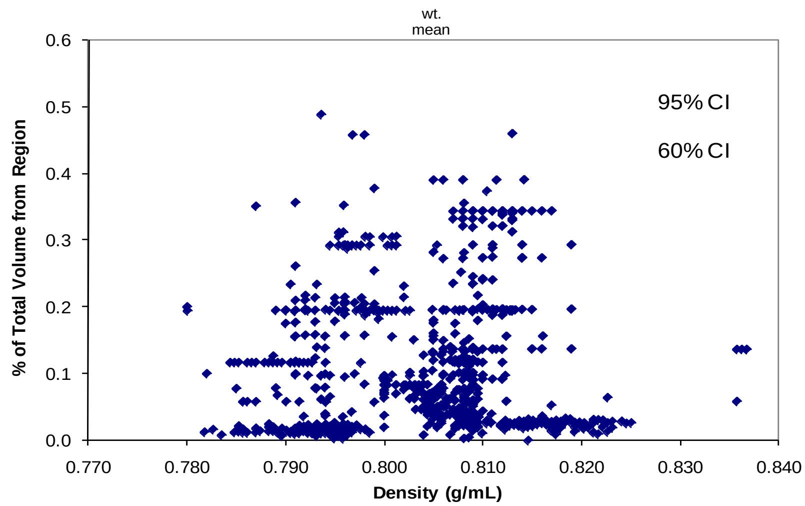

Figure 26. 2001 PQIS Density Data for Region 3.

As shown in Figure 26, the data is slightly right-skewed. The symmetry of the confidence intervals indicates the data maintains a relatively normal shape. Due to a number of low volumes of fuel procurements with high density, the right-skewed form of the lognormal distribution fits the data for Region 3. Figure 27 shows the lognormal distribution curves for the years 1999-2008 from Region 3. The distribution curves for all ten years have consistent shapes. The curves are slightly shifted for some years due to differences in the mean values. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

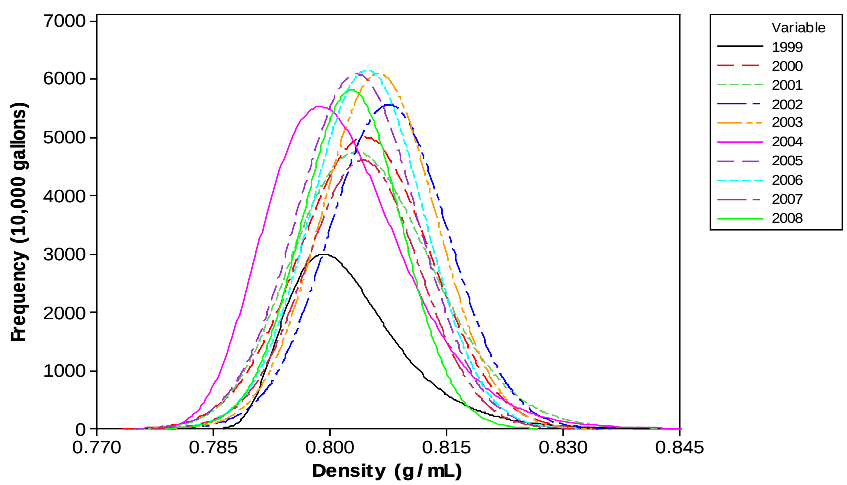

Figure 27. Histogram of the Lognormal Distribution Fit Curves of the PQIS Density Data for Region 3 from 1999-2008.

The density data is consistently right-skewed, but remains a relatively normal shape throughout the years 1999-2008. There exists a slight variation throughout the years in the volume of fuel procured in Region 3 with low or high density. *In general, the density of fuel procured in Region 3 has been consistent within a range of 0.792 to 0.815 g/mL with a mean value of approximately 0.805 g/mL throughout the years 1999-2008.*

3.1.2.4. Region 4

Table 12 shows the calculated weight mean and 80% confidence interval of the density from the 1999-2008 PQIS data for Region 4 of CONUS. With the exception of 1999, 2000, 2002 and 2007, the weight mean density is consistently about 0.803 g/mL. The years 1999 and 2000 have a slightly lower mean density of 0.800 g/mL due to the procurement of a larger volume of fuel with lower density and few procurements of fuel with high density. In 2002 and 2007, there were a few high volume procurements of fuel with high density resulting in a higher weight mean of 0.806 g/mL. In Region 4, there are a low number of fuel procurements. The few fuel procurements in each year of Region 4 have considerable variation in density ranging from 0.780 to 0.840 g/mL. This variation causes the slight difference in weighted means and 80% confidence intervals throughout the years, shown in Table 12.

Table 12. Density Statistics for Region 4.

Year	Wt mean	80% CI
1999	0.800	(0.796, 0.807)
2000	0.800	(0.795, 0.805)
2001	0.803	(0.797, 0.808)
2002	0.806	(0.796, 0.817)
2003	0.803	(0.798, 0.809)
2004	0.803	(0.799, 0.809)
2005	0.802	(0.796, 0.811)
2006	0.803	(0.795,0.817)
2007	0.806	(0.794, 0.825)
2008	0.804	(0.797, 0.813)

Due to the variation in the density of fuel procured in Region 4, the confidence intervals are not consistent throughout most of the years in Region 4. Figure 28 shows each individual fuel procurement in Region 4 based on the data from 2001. For each fuel procurement, the density and corresponding percent of total volume from Region 4 are shown. The weighted mean density is 0.803 g/mL and the 95% and 60% confidence intervals are shown. The low number of fuel procurements and variation in density can be observed in Figure 28.

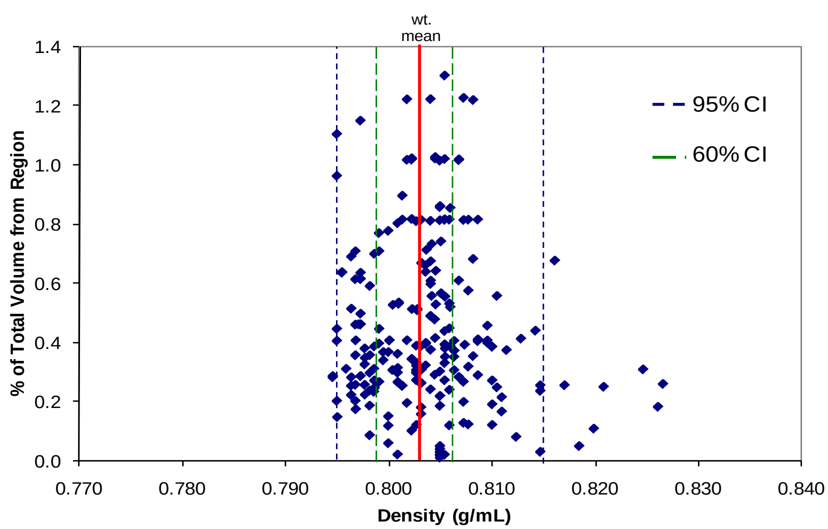

Figure 28. 2001 PQIS Density Data for Region 4.

As shown by the position of the 95% confidence interval in Figure 28, the data is right-skewed. Due to low volume fuel procurements with high density, the right-skewed form of the loglogistic distribution fits the data for Region 4. Figure 29 shows the loglogistic distribution curves for the years 1999-2008 from Region 4. With the exception of 2002 and 2007, the distribution curves have a consistent shape for all years. The distribution curve for 2002 and 2007 are less skewed due to a larger volume of high density and few low density procurements than in other years.

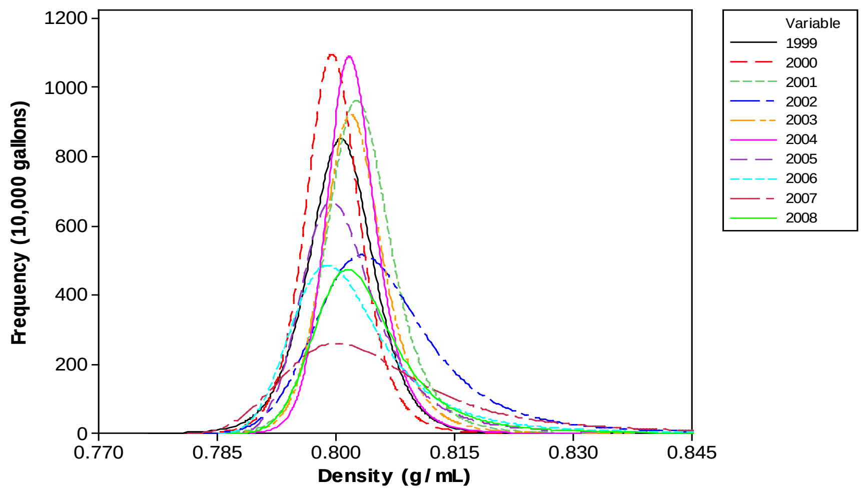

Figure 29. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Density Data for Region 4 from 1999-2008.

The density data was consistently right-skewed throughout the years 1999-2008. The procurement and volume of fuel with very low and/or high density was not consistent in the years 1999-2008. The range in density, as well as the volume of each fuel procurement in Region 4, varies slightly throughout all years. *However, with the exception of 2002 and 2007, the density of fuel procured in Region 4 has been consistent within a range of 0.792 to 0.817 g/mL with a mean value of 0.803 g/mL.*

3.1.2.5. Region 5

Table 13 shows the calculated weight mean and 80% confidence interval of the density from the 1999-2008 PQIS data for Region 5 of CONUS. The weight mean of the density are consistently about 0.820 g/mL throughout all ten years. The 80% confidence intervals are fairly consistent throughout all years. Slight variations in weight mean and 80% confidence intervals are due to the procurement of a higher volume of fuel with high density than other years.

Table 13. Density Statistics for Region 5.

Year	Wt mean	80% CI
1999	0.823	(0.812, 0.836)
2000	0.819	(0.810, 0.838)
2001	0.820	(0.810, 0.837)
2002	0.821	(0.810, 0.835)
2003	0.822	(0.809, 0.836)
2004	0.823	(0.808, 0.836)
2005	0.818	(0.807, 0.832)
2006	0.818	(0.809, 0.829)
2007	0.819	(0.810, 0.835)
2008	0.819	(0.812, 0.832)

Although the weighted means throughout all years in Region 5 are relatively consistent, the 95% and 90% confidence intervals are not consistent. The variation in the volume of the fuel procurements and density causes differences in the confidence intervals, which become balanced when calculating the average. This results in the similar weight means shown in Table 12. Figure 30 shows each individual fuel procurement in Region 5 based on the data from 2001. For each fuel procurement, the density and corresponding percent of total volume from Region 5 are shown. The weighted mean density is 0.820 g/mL and the 95% and 60% confidence intervals are shown. The relatively even dispersal of the size of the fuel procurements and the density can be observed in Figure 30.

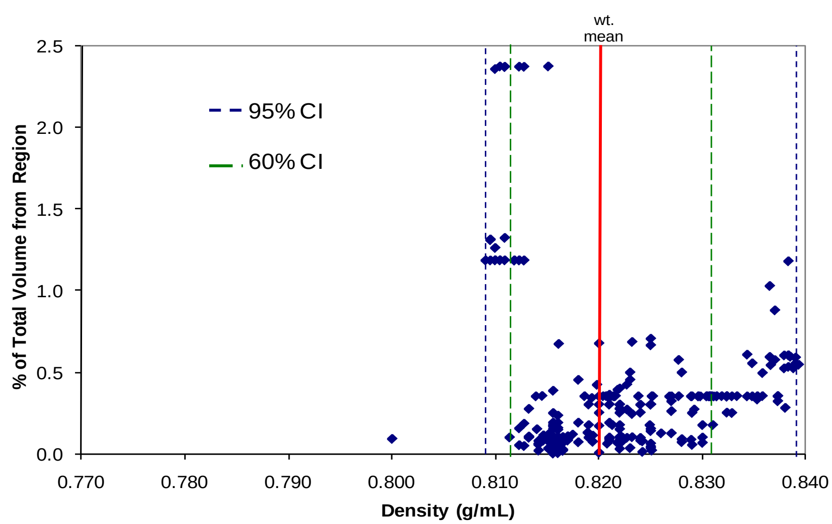

Figure 30. 2001 PQIS Density Data for Region 5.

As shown in Figure 30 by the position of the 95% confidence interval, the data is right-skewed. The symmetry of the 60% confidence interval indicates the data maintains a relatively normal shape. Due to a few number of larger procurements with low density and lower volume procurements with high density, the right-skewed form of the lognormal distribution fits the data for Region 5. Figure 31 shows the lognormal distribution curves for the years 1999-2008 from Region 5. The distribution curves for all ten years in Region 5 have consistent shapes. The curves are slightly shifted for some years due to small differences in the mean values.

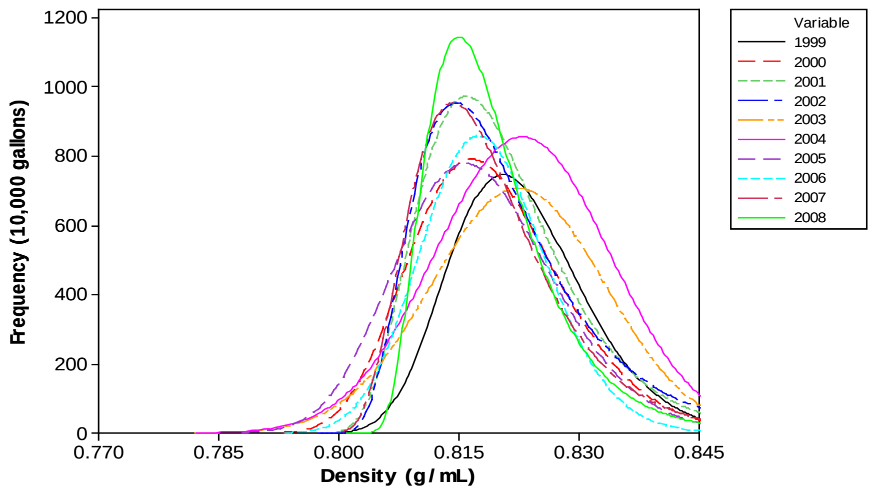

Figure 31. Histogram of the Lognormal Distribution Fit Curves of the PQIS Density Data for Region 5 from 1999-2008.

The density data is consistently right-skewed throughout the years 1999-2008. Some variation exists in the number and volume of fuel procurements with low and/or high density causing inconsistencies in the 95% and 90% confidence intervals. *In general, the density of fuel procured in Region 5 has been consistent within a range of 0.805 to 0.838 g/mL with a mean value of approximately 0.820 g/mL throughout the years 1999-2008.*

3.1.2.6. CONUS

Table 14 shows the calculated weight mean and 80% confidence interval of the density from the 1999-2008 PQIS data for Regions 1-5 of CONUS combined. The weight mean of density is consistently 0.807 g/mL throughout the years with the exception of 2002 and 2003 being slightly greater at 0.810 and 0.809 g/mL, respectively. The lower bounds in the 80% confidence intervals are consistent for all ten years. There is a slight variation in the upper bounds of the confidence intervals due to differences in fuel volume with high density procured in each year.

Table 14. Density Statistics for CONUS.

Year	Wt mean	80% CI
1999	0.807	(0.795, 0.824)
2000	0.807	(0.796, 0.817)
2001	0.808	(0.796, 0.821)
2002	0.810	(0.799, 0.824)
2003	0.809	(0.798, 0.826)
2004	0.807	(0.792, 0.829)
2005	0.806	(0.793, 0.818)
2006	0.807	(0.796, 0.818)
2007	0.808	(0.794, 0.822)
2008	0.807	(0.794, 0.817)

Since the weighted means are consistent throughout all years in CONUS, the confidence intervals are fairly consistent. Figure 32 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the density and corresponding percent of total volume from CONUS are shown. The weighted mean density is 0.807 g/mL and the 95% and 60% confidence intervals are shown. Figure 32 shows the low volume fuel procurements with lower and higher density than the weight mean.

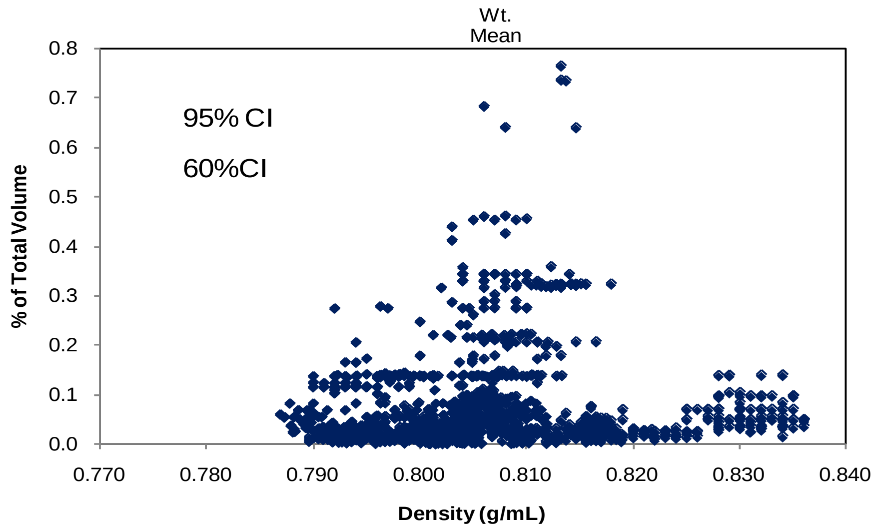

Figure 32. 2008 PQIS Density Data for Regions 1-5.

As shown in Figure 32 by the position of the 95% confidence interval, the data is right-skewed. The appearance of an almost normal distribution in the 60% confidence interval is caused by the large number of fuel procurements with density within a consistent range. Due to a number of low volume fuel procurements with high density, the right-skewed form of the lognormal distribution fits the data for CONUS. Figure 33 shows the lognormal distribution curves for the years 1999-2008 from CONUS. The distribution curves for all ten years in CONUS have consistent shapes and positions. The volume of fuel procured from Regions 3 and 5, which both have a lognormal probability distribution, together account for almost eighty percent of the total fuel procured annually within CONUS. Thus it is not surprising that the data for CONUS combined also has a lognormal probability distribution.

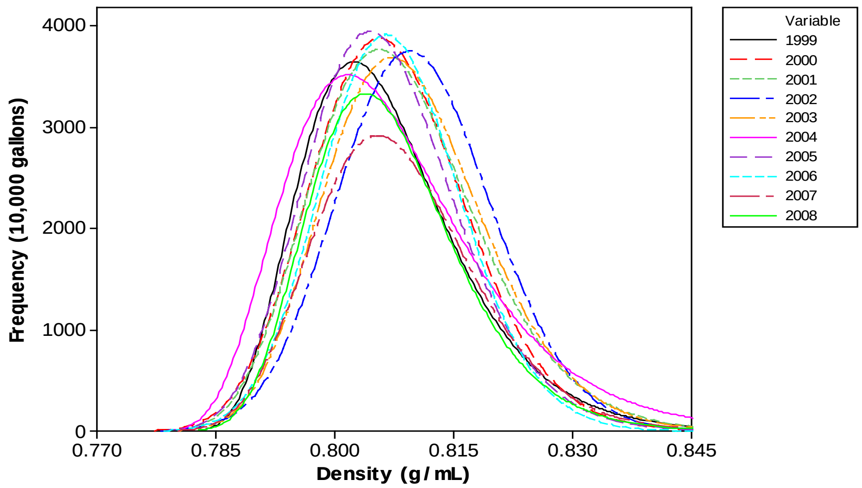

Figure 33. Histogram of the Lognormal Distribution Fit Curves of the PQIS Density Data for CONUS from 1999-2008.

The density data for CONUS combined is consistently right-skewed. Throughout the years 1999-2008, there have consistently been fuel quantities procured in small volumes which have high density and large volumes which have a density ranging from 0.797 to 0.815 g/mL. *In general, the density of fuel procured in CONUS has been consistent within a range of 0.792 to 0.825 g/mL with a mean value about 0.807 g/mL throughout the years 1999-2008.*

3.1.2.7. Variability of Density as a Function of Region

Table 15 shows the calculated weight mean and 80% confidence interval of the density from the PQIS data for Regions 1-5 of CONUS from the combined years 1999-2008. The mean density value for Regions 1, 3, and 4 is consistently about 0.804 g/mL and slightly higher at 0.807 g/mL for Region 2 and CONUS combined. Region 5 has the highest mean value of 0.820 g/mL due to the procurement of a low volume of fuel with a density of less than 0.800 g/mL. The weight mean for CONUS combined is slightly higher than the weight mean of Regions 1-4, due to the high density of fuel procured in Region 5. The 80% confidence intervals are consistent for Regions 1, 3, and 4 due to similar volume and range of the density of fuel procured in these regions. The upper and lower bounds of the 80% confidence interval for Region 5 are higher than in other regions due to the procurement of high density fuel. The overlap in the confidence intervals is representative of the range of density consistent within each region. However, the differences in the upper and lower bounds of the confidence intervals are too significant to disregard. Thus the range in the density of fuel procured within each region may need to be considered separately. The calculated weight mean density as a function of year from 1999-2008 for Regions 1-5 of CONUS is shown in Figure 34. It is apparent that consistent trends independently exist within Regions 2-5 and CONUS combined. The density is Region 1 has shown a wide range of variability throughout 1999-2008, which is intensified by the low total volume of fuel procured in this region. The fuel procured in Region 5 has consistently had the highest mean density of all regions with little variation throughout all years.

Table 15. Density Statistics for All Years.

Region	Mean	60% CI	80% CI
1	**	**	**
2	0.807	0.804 - 0.810	0.801 – 0.812
3	0.805	0.797 - 0.810	0.793 – 0.813
4	0.803	0.798 - 0.812	0.797 – 0.817
5	0.820	0.811 - 0.832	0.810 – 0.835
CONUS	0.807	0.799 - 0.813	0.795 – 0.820
** Not consistent for consecutive years, cannot be predicted.			

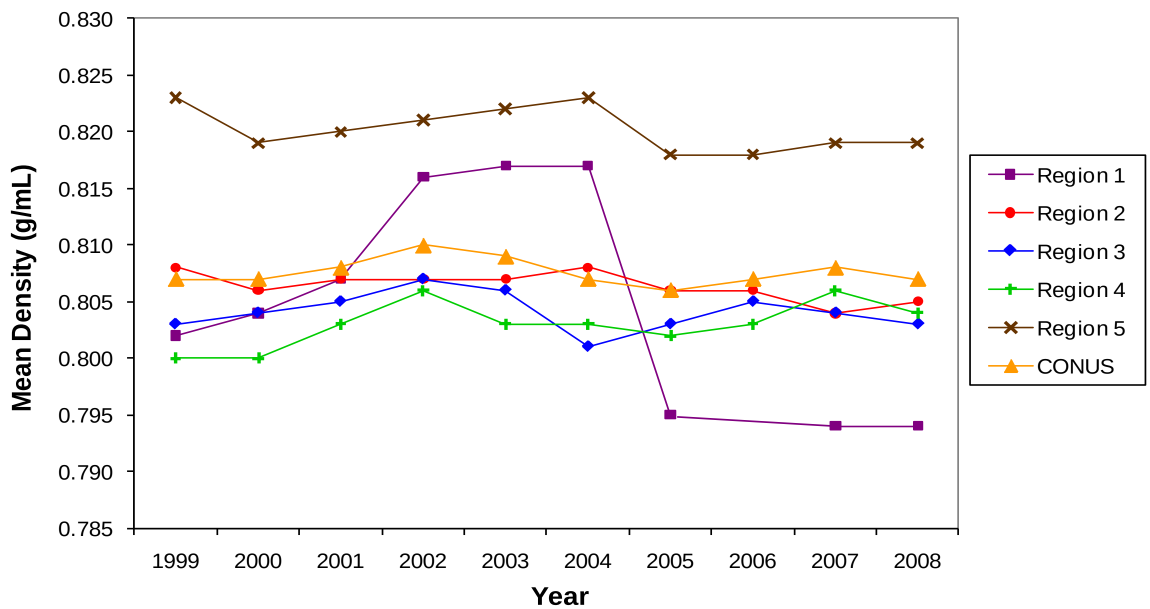

Figure 34. Weight Mean Density from Years 1999-2008 as a Function of Region and CONUS.

Figure 35 shows each individual fuel procurement in each region based on the combined data from 1999-2008. For each fuel procurement, the density and corresponding percent of total volume from each region are shown. The fuel procured in each region has a wide range of density. As shown in Figure 35, there is no consistent distribution of data between all five regions. With such statistical differences between the densities of the fuel between most of the regions, the regions may need to be considered independently when analyzing property distributions and changes over time. If all regions of CONUS were considered as one, the density of a portion of the fuel procured in Regions 1, 3 and 4 would be overestimated and Region 5 would be underestimated resulting in inaccurate predictions.

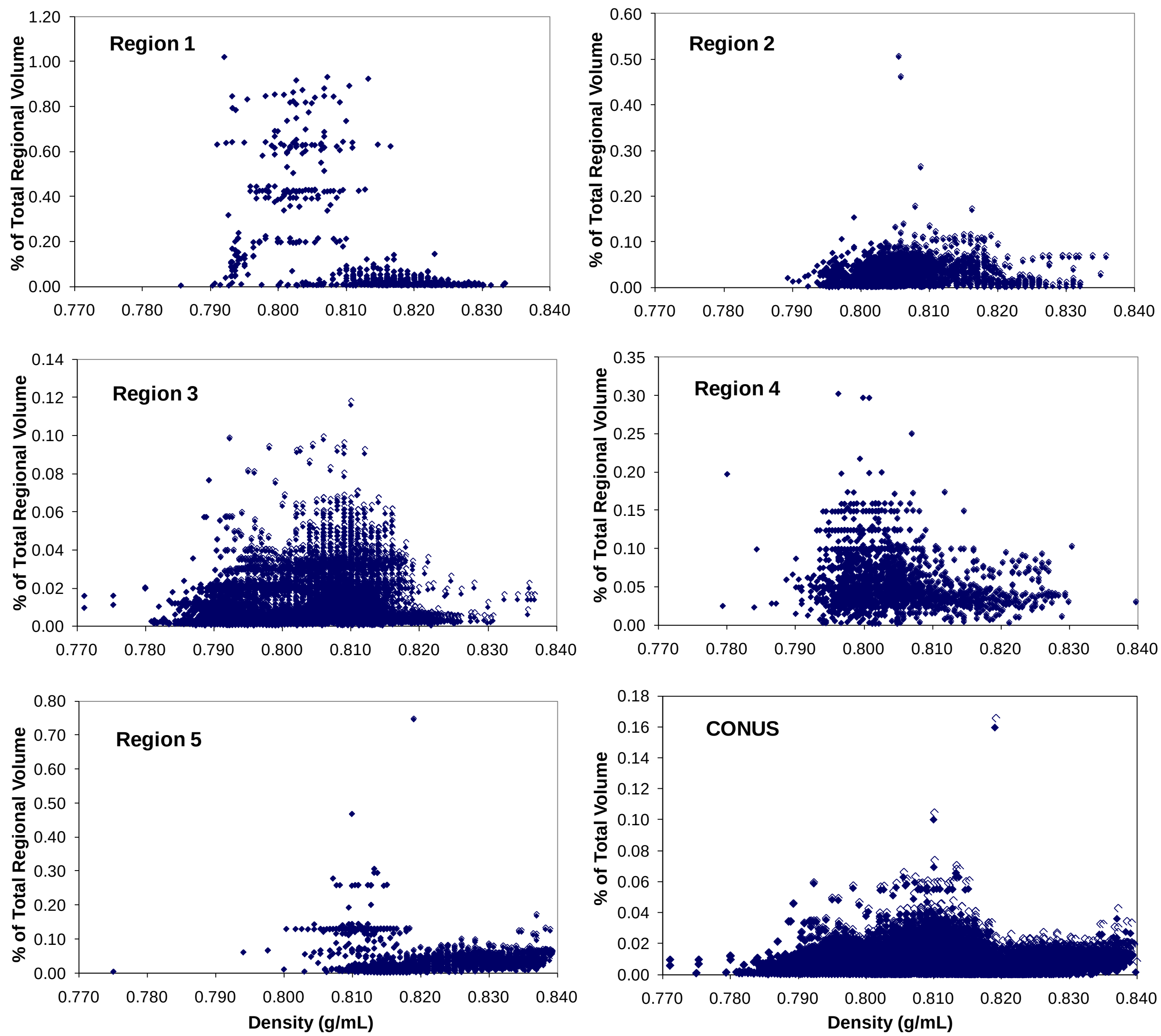

Figure 35. Combined PQIS Density Values from 1999-2008 as a Function of Region.

3.1.2.8. Summary of Density Analysis

Based on the historical density data, there is no consistency in the density of fuel procured throughout all years in Region 1. There is a distinct increase in the density of fuel procured in the years 1999-2001, 2005, and 2007-2008 (0.800 g/mL) to the fuel procured in 2002-2004 (0.817 g/mL). The density of fuel procured in 2005 and 2007-2008 (0.794 g/mL) is slightly lower than in 1999-2001 since there was a lower volume of high density fuel procured. The range in the density as well as the volume of each fuel procurement in Region 1 is not consistent for more than three consecutive years from 1999-2008. Therefore, the density of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of historical trends.

In Regions 2-5, there are trends in the historical density data that can be useful in predicting density of fuels from these regions. The density of fuel procured in Region 2 has been consistent within a range of 0.799 to 0.818 g/mL with a mean value of 0.807 g/mL. Due to the procurement of a large volume of fuel with lower density and only a few high volume procurements of fuel with high density, the right-skewed form of the loglogistic distribution fits the data for Region 2. The density of fuel procured in Region 3 has been consistent within a range of 0.792 to 0.815 g/mL with a mean value of approximately 0.805 g/mL. The right-skewed form of the lognormal distribution fits the data for Region 3 because of a number of low volume fuel procurements with high density. With the exception of 2002 and 2007, the density of fuel procured in Region 4 has been consistent within a range of 0.792 to 0.817 g/mL with a mean value of 0.803 g/mL. Due to low volume fuel procurements with high density, the right-skewed form of the loglogistic distribution fits the data for Region 4. The density of fuel procured in Region 5 has been consistent within a range of 0.805 to 0.838 g/mL with a mean value of approximately 0.820 g/mL. Due to a small number of large volume procurements with low density and low volume procurements with high density, the right-skewed form of the lognormal distribution fits the data for Region 5.

From the analysis of the density of each region, it is apparent that consistent trends independently exist within Regions 2-5 and CONUS combined. The density of fuel procured in Region 1 has shown a wide range of variability throughout 1999-2008. The density of fuel procured in CONUS has been consistent within a range of 0.792 to 0.825 g/mL with a mean value about 0.807 g/mL. The data for CONUS is right-skewed due to a number of low volume fuel procurements with high density. Although the combined analysis of all regions was consistent, the difference between individual regions is too substantial to disregard and analyze all regions together. A summary of trends in density mean statistics and 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 16. With the exception of Region 1, the density of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 16.

Table 16. Overall Density Statistics for Each Region and CONUS Based on PQIS Data for 1999-2008.

Region	Mean	60% CI	80% CI
1	**	**	**
2	0.807	0.804 - 0.810	0.801 – 0.812
3	0.805	0.797 - 0.810	0.793 – 0.813
4	0.803	0.798 - 0.812	0.797 – 0.817
5	0.820	0.811 - 0.832	0.810 – 0.835
CONUS	0.807	0.799 - 0.813	0.795 – 0.820
** Not consistent for consecutive years, cannot be predicted.			

Overall, analysis of the density as a function of year and region for JP-8 procured from 1999-2008 has shown relatively consistent mean values and variation exist within individual regions and CONUS. However, there are statistical differences between fuels procured in different regions. The prediction of the density of fuel based solely on the analysis of CONUS combined would render a statistically inaccurate estimation of the density. Therefore, the predictability of the density of JP-8 is dependent on the region of CONUS in which the fuel is procured.

3.1.3. Statistics and Distribution for Freeze Point

The MIL-DTL-83133F fuel specification requires JP-8 to have a maximum (<) freeze point of -47.0°C. The following section analyzes the PQIS freeze point data from regions 1-5 of CONUS for the years 1999-2008. The complete detailed analysis of the freeze point, the correlation of the distribution with the PQIS data, and the confidence intervals based on the PQIS data and distribution as a function of region and year is included in Appendix A. The weight mean freeze point and 80% confidence interval are listed for each year in the regions of CONUS within this discussion. The 80% confidence interval is representative of the variation in volume and/or the freeze point of fuel based on the position of the weight mean within the confidence interval and provides guidance regarding general variability in the data. During analysis, the percent of total volume of fuel procured within the region for a given year is also plotted as a function of the reported PQIS freeze point of the fuel. The 95% confidence interval is labeled on the figures to demonstrate the range in the value of the freeze point since a large percentage of the data falls within these intervals. The 60% confidence interval shows the focal or center range in which the value of the freeze point is likely to fall. The data from 1999 for Regions 1-5 and from 2008 for CONUS is plotted in these figures for each region since a large volume of fuel was procured during these years and the relative distribution is representative of fuel procured within a specific region.

3.1.3.1. Region 1

Table 17 shows the calculated weight mean and 80% confidence interval of the freeze point from the 1999-2005 and 2007 PQIS data for Region 1 of CONUS. No JP-8 fuel was reported as being procured in Region 1 of CONUS in 2006. The weight mean freeze point is consistently about -58.0ºC for 1999-2003, and consistently higher in 2004, 2005, and 2007 at -53.4ºC, -49.4ºC, and -49.7ºC, respectively. In the years 2004, 2005, and 2007, a larger volume of fuel was procured with a high freeze point than in the previous years, resulting in the higher weight means. The weight mean of 2002 is slightly lower at -61.0ºC due to the procurement of a number of large volumes of fuel with low freeze point. The 80% confidence intervals are consistent for most years that have similar weight means (1999-2001 and 2004-2007). The upper and lower bounds of the 80% confidence interval in 2002 and 2003 are lower than in 1999-2001 due to a larger volume of fuel procured with low freeze point in those year.

Table 17. Freeze Point Statistics for Region 1.

Year	Wt mean	80% CI
1999	-56.9	(-61.0, -54.0)
2000	-57.4	(-61.0, -54.0)
2001	-58.2	(-64.0, -55.0)
2002	-61.0	(-66.0, -51.5)
2003	-58.0	(-66.0, -52.0)
2004	-53.4	(-57.0, -49.9)
2005	-49.4	(-52.0, -48.9)
2007	-49.7	(-51.0, -48.9)

In the years with similar weight means, the confidence intervals were consistent. In Region 1, there were few fuel procurements recorded for each year. The low number of fuel procurements reported fall within a large range of volume and freeze point values and some are recorded above the maximum specification of -47.0ºC. Thus the freeze point of fuel procured in Region 1 is not consistent throughout all years. Figure 36 shows each individual fuel procurement in Region 1 based on the data from 1999. For each fuel procurement, the freeze point and corresponding percent of total volume from Region 1 are shown. The weighted mean freeze point was -56.9ºC and the 95% and 60% confidence intervals are shown.

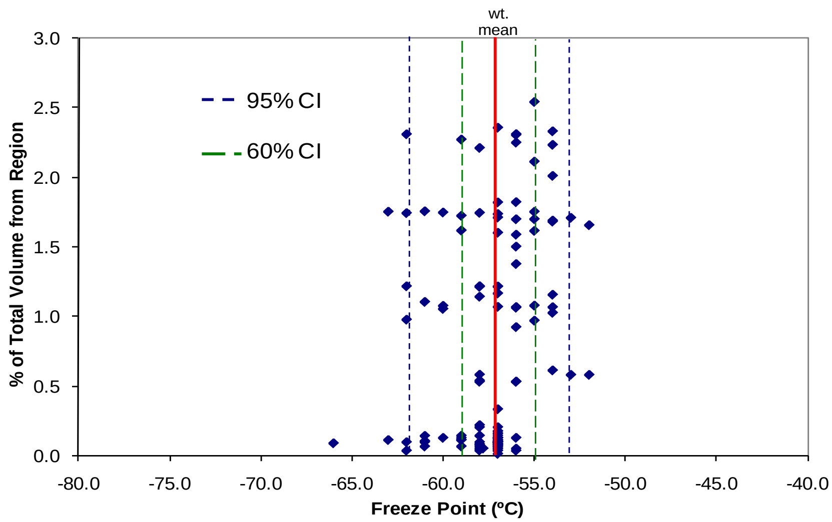

Figure 36. 1999 PQIS Freeze Point Data for Region 1.

As shown in Figure 36 by the position of the 95% confidence interval, the freeze point data is left-skewed. This type of distribution is logical as the fuel must meet the maximum freeze point specification; fuel producers will not want to further process the fuels to reduce the freeze point further. Due to the large volume fuel procurements with high freeze point and smaller volume procurements of lower freeze point within each year, the left-skewed form of the weibull probability distribution fits the data for Region 1. Figure 37 shows the weibull distribution curves for the years 1999-2007 from Region 1. Since the y-axis is the volume of fuel procured for a specific freeze point, the variation in the height of the curves is due to the differing volumes of fuel procured within each year. The years with similar weighted mean (1999-2001) have distribution curves with consistent shapes and locations along the x-axis.

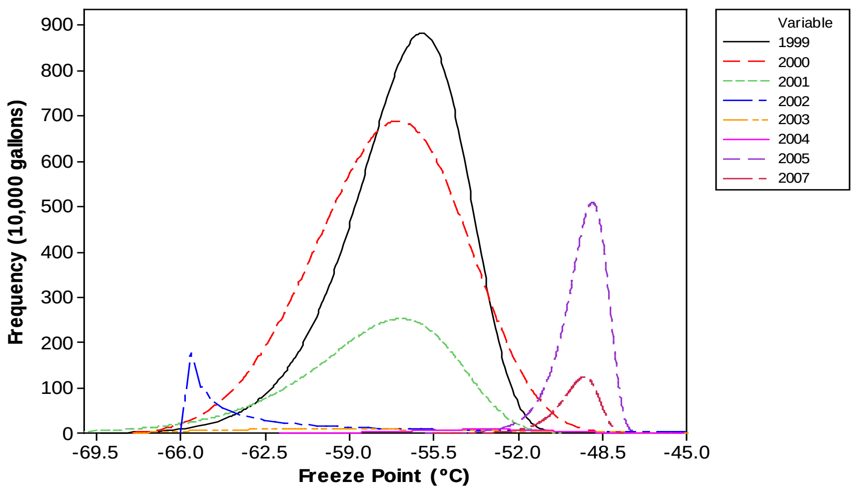

Figure 37. Histogram of the Weibull Distribution Fit Curves of the PQIS Freeze Point Data for Region 1 from 1999-2007.

There is a distinct increase in the average freeze point of fuel procured in the years 1999-2001 and 2003 (-58.0ºC) to the fuel procured in 2004, 2005 and 2007 (-53.4, -49.4, and -49.7ºC). However, there was a decrease in the freeze point in 2002 to -61.0ºC due to the procurement of a large volume of fuel with low freeze point. The range in the freeze point as well as the volume of each fuel procured in Region 1 is not consistent for more than three consecutive years from 1999-2007. *Therefore, the freeze point of fuel procured in Region 1 cannot be predicted with a high degree of certainty*. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of trends for CONUS combined.

3.1.3.2. Region 2

Table 18 shows the calculated weight mean and 80% confidence interval of the freeze point from the 1999-2008 PQIS data for Region 2 of CONUS. With the exception of 2001-2002 and 2007-2008, there is a clear consistency in the weight mean freeze point of approximately -50.0ºC throughout all years. The weight mean freeze point in these years is slightly lower at about -51.5ºC due to a few high volume fuel procurements with low freeze point. The 80% confidence intervals are fairly consistent for the years with similar weight means (1999-2000, 2003-2006 and 2001-2002, 2007-2008). There is a slight variation in the lower bounds of the confidence intervals due to differing volumes of fuel procured with a low freeze point within each year.

Table 18. Freeze Point Statistics for Region 2.

Year	Wt mean	80% CI
1999	-50.6	(-54.0, -48.2)
2000	-50.5	(-54.0 -48.1)
2001	-51.6	(-59.0, -48.0)
2002	-51.3	(-59.0, -48.0)
2003	-50.0	(-53.6, -47.8)
2004	-50.0	(-53.0, -47.9)
2005	-49.8	(-52.1, -48.2)
2006	-50.3	(-52.2, -48.3)
2007	-51.5	(-54.6, -48.3)
2008	-51.9	(-54.6, -48.3)

Although the mean values are consistent for most years in Region 2, the 95% and 90% confidence intervals are not consistent. There is a variation in the lower bound of these confidence intervals due to differing volumes of fuel procured with a low freeze point throughout the years. Figure 38 shows each individual fuel procurement in Region 2 based on the data from 1999. For each fuel procurement, the freeze point and corresponding percent of total volume from Region 2 are shown. The weighted mean freeze point is -50.6ºC and the 95% and 60% confidence intervals are shown.

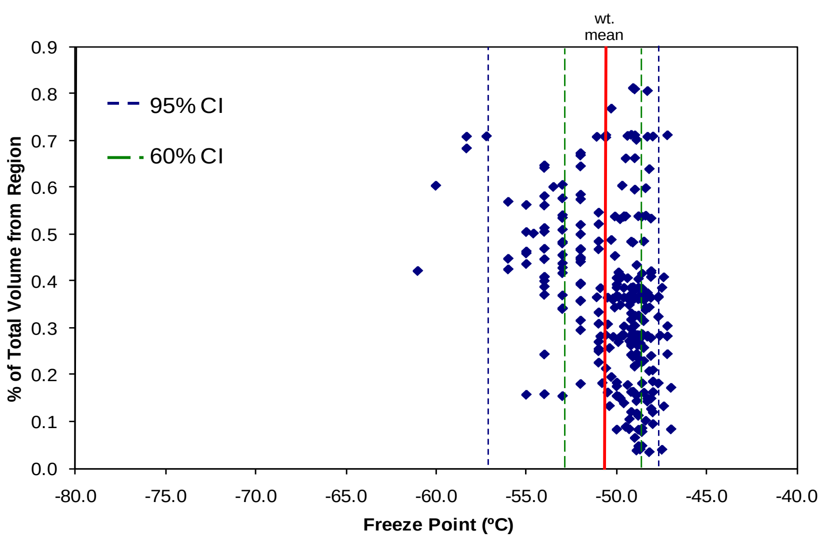

Figure 38. 1999 PQIS Freeze Point Data for Region 2.

As shown in Figure 38 by the confidence intervals, the data is left-skewed. Due to the procurement of more fuel with freeze point near the maximum specification of -47.0ºC and only a few high volume procurements of fuel with low freeze point, the left-skewed form of the smallest extreme value distribution fits the data for Region 2. Figure 39 shows the smallest extreme value distribution curves for the years 1999-2008 from Region 2. The distribution curves for all ten years in Region 2 have consistent shapes. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

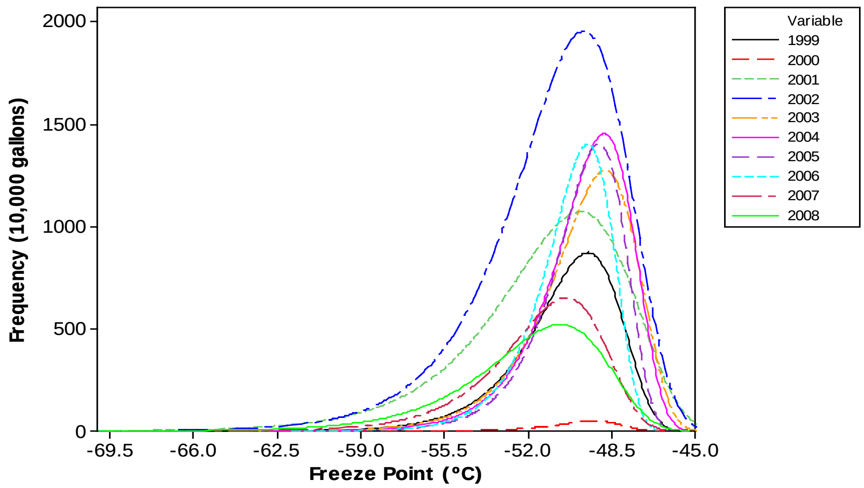

Figure 39. Histogram of the Smallest Extreme Value Distribution Fit Curves of the PQIS Freeze Point Data for Region 2 from 1999-2008.

The freeze point data is consistently left-skewed throughout the years 1999-2008. Some variation exists in the number and volume of fuel procurements with low freeze point causing slight differences in skewness and position of the distribution curves on the x-axis. *In general, the freeze point of fuel procured in Region 2 has been consistent within a range of -60.0 to -47.0ºC with a mean value of -50.0ºC throughout the years 1999-2008.*

3.1.3.3. Region 3

Table 19 shows the calculated weight mean and 80% confidence interval of the freeze point from the 1999-2008 PQIS data for Region 3 of CONUS. With the exception of 1999 and 2004, all years have a consistent weight mean freeze point of approximately -52.0ºC. The mean freeze point of these years is slightly higher at about -50.0ºC due to the procurement of a smaller volume of fuel with a low freeze point than in the other years. The 80% confidence intervals are all within a consistent range since the freeze point of a majority of the fuel procured in each year falls within the same range. The lower bounds of the 80% confidence intervals in 1999 and 2004 are slightly higher because less fuel was procured with a low freeze point.

Table 19. Freeze Point Statistics for Region 3.

Year	Wt mean	80% CI
1999	-50.5	(-54.0, -48.0)
2000	-52.3	(-58.0, -48.0)
2001	-52.7	(-59.0, -48.0)
2002	-52.6	(-60.0, -48.0)
2003	-52.9	(-60.0, -48.3)
2004	-50.7	(-54.7, -48.0)
2005	-51.3	(-56.8, -48.0)
2006	-51.9	(-57.0, -48.2)
2007	-52.1	(-57.0, -48.0)
2008	-51.4	(-56.4, -48.0)

In Region 3, the confidence intervals are comparatively consistent for all ten years. Figure 40 shows each individual fuel procurement in Region 3 based on the data from 1999. For each fuel procurement, the freeze point and corresponding percent of total volume from Region 3 are shown. The weighted mean freeze point is -50.5ºC and the 95% and 60% confidence intervals are shown. Figure 40 shows the few fuel procurements with a low freeze point that cause the slight variation in weighted mean between the years

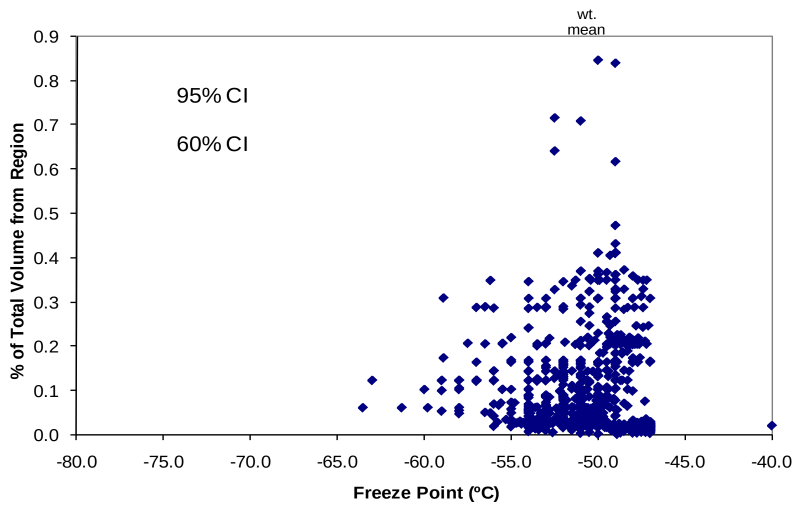

Figure 40. 1999 PQIS Freeze Point Data for Region 3.

As shown in Figure 40, the data is left-skewed. Due to the procurement of more fuel with freeze point near the maximum specification of -47.0ºC and only a few procurements of fuel with low freeze point, the left-skewed form of the smallest extreme value distribution fits the data for Region 3. Figure 41 shows the smallest extreme value distribution curves for the years 1999-2008 from Region 3. The distribution curves for all ten years in Region 3 have consistent shapes. The curves are slightly shifted for some years due to differences in the mean values. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

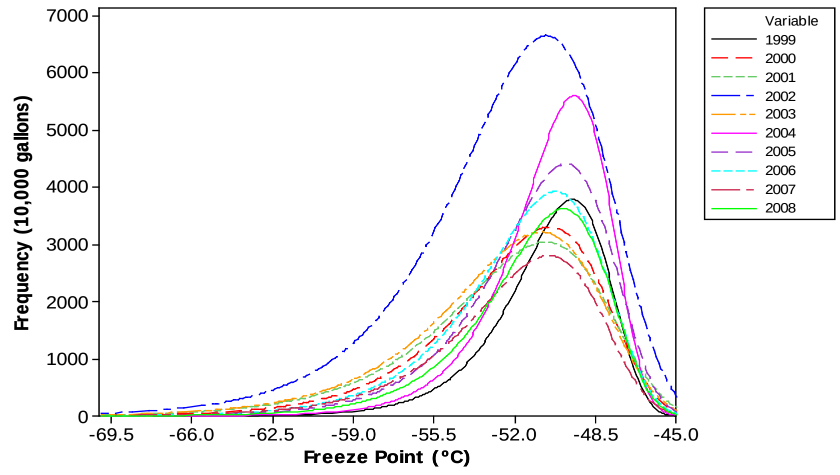

Figure 41. Histogram of the Smallest Extreme Value Distribution Fit Curves of the PQIS Freeze Point Data for Region 3 from 1999-2008.

The freeze point data is consistently left-skewed throughout the years 1999-2008. There exists a slight variation throughout the years in the volume of fuel procured in Region 3 with a low freeze point. *In general, the freeze point of fuel procured in Region 3 has been consistent within a range of -62.0 to -47.0ºC with a mean value about -52.0ºC throughout the years 1999-2008.*

3.1.3.4. Region 4

Table 20 shows the calculated weight mean and 80% confidence interval of the freeze point from the 1999-2008 PQIS data for Region 4 of CONUS. There is variation in the freeze point of fuel procured in 1999-2000, 2002, and 2004-2005 (-50.0 ºC) and in 2001 and 2003 (-51.2ºC). In the years 2006-2008 there is a slight decline in weight mean freeze point to -52.0 ºC due to the procurement of a larger volume of fuel with lower freeze point than the other years. In Region 4, there are a low number of fuel procurements. The few fuel procurements in each year of Region 4 have considerable variation in freeze point ranging from -82.0 to -47.0ºC. This variation causes the slight difference in weighted means and the lower bounds of the 80% confidence intervals throughout the years, as shown in Table 20.

Table 20. Freeze Point Statistics for Region 4.

Year	Wt mean	80% CI
1999	-50.0	(-54.0, -47.8)
2000	-50.3	(-53.0, -48.0)
2001	-51.3	(-56.0, -48.0)
2002	-50.5	(-54.0, -48.0)
2003	-51.2	(-55.0, -49.0)
2004	-49.5	(-51.5, -48.0)
2005	-49.8	(-51.5, -48.0)
2006	-51.9	(-57.5, -49.0)
2007	-52.1	(-56.0, -48.9)
2008	-52.2	(-58.0, -48.0)

Due the variation in the freeze point of fuel procured in Region 4, the lower bounds of the confidence intervals are inconsistent throughout most of the years. Figure 42 shows each individual fuel procurement in Region 4 based on the data from 1999. For each fuel procurement, the freeze point and corresponding percent of total volume from Region 4 are shown. The weighted mean freeze point is -50.0ºC and the 95% and 60% confidence intervals are shown. The low number of fuel procurements and variation in freeze point as shown in Figure 42.

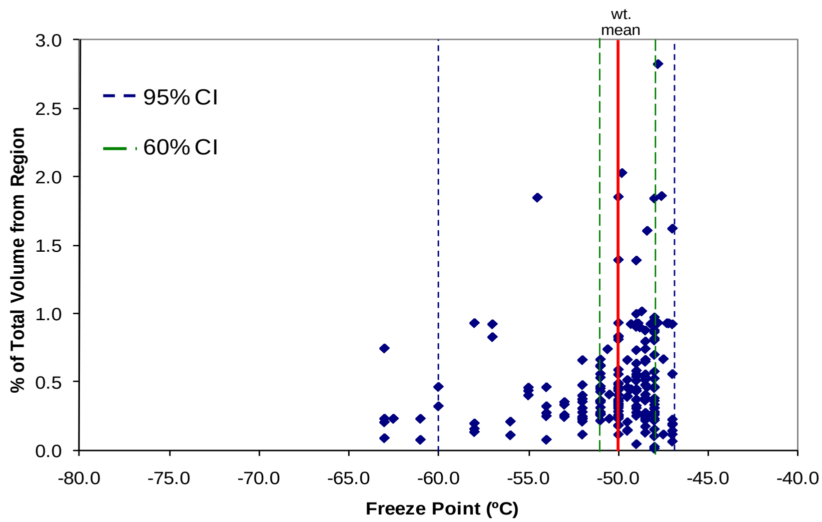

Figure 42. 1999 PQIS Freeze Point Data for Region 4.

As shown by the position of the 95% confidence interval in Figure 42, the data is left-skewed. Due to the procurement of a high volume of fuel with freeze point near the maximum specification of -47.0ºC and only a few procurements of fuel with a low freeze point, the left-skewed form of the smallest extreme value distribution fits the data for Region 4. Figure 43 shows the smallest extreme value distribution curves for the years 1999-2008from Region 4. The distribution curves have a consistent shape for all years. Slight variations in the skewness and position of the curves are caused by the procurement of different volumes of low freeze point fuel in each year.

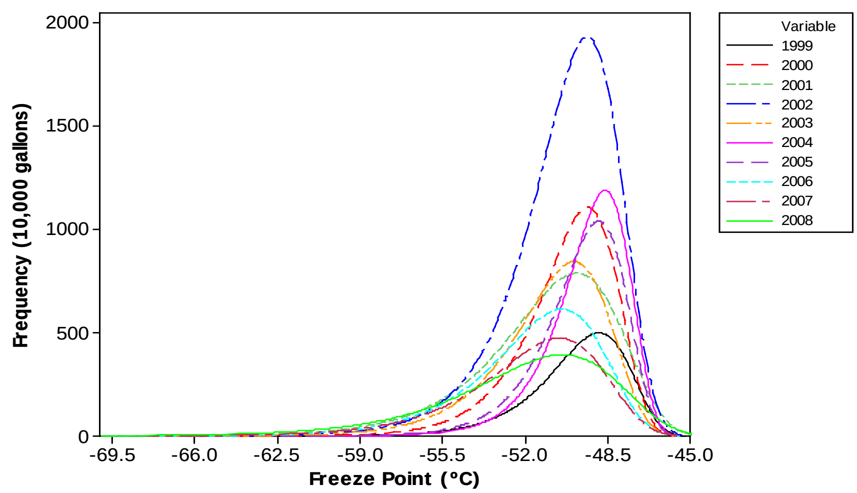

Figure 43. Histogram of the Smallest Extreme Value Distribution Fit Curves of the PQIS Freeze Point Data for Region 4 from 1999-2008.

The freeze point data was consistently left-skewed throughout the years 1999-2008. However, the procurement and volume of fuel with very low freeze point was not consistent in the years 1999-2008. The range in freeze point as well as the volume of each fuel procurement in Region 4 varies slightly throughout all years. *Overall, the freeze point of fuel procured in Region 4 has been consistent within a range of -60.0 to -47.0ºC with a mean value of -51.0ºC throughout the years 1999-2008.*

3.1.3.5. Region 5

Table 21 shows the calculated weight mean and 80% confidence interval of the freeze point from the 1999-2008 PQIS data for Region 5 of CONUS. The weight mean of the freeze point are consistently about -55.0ºC throughout all ten years. The 80% confidence intervals are fairly consistent throughout all years. Any slight variations in weight mean and 80% confidence intervals are due to the variation in the volume of fuel procured with a low freeze point within each year.

Table 21. Freeze Point Statistics for Region 5.

Year	Wt mean	80% CI
1999	-53.9	(-63.0, -48.0)
2000	-54.6	(-63.0, -49.0)
2001	-55.0	(-65.0, -48.0)
2002	-55.4	(-65.0, -48.0)
2003	-57.0	(-66.0, -49.0)
2004	-54.8	(-65.0, -48.0)
2005	-56.0	(-65.0, -48.0)
2006	-54.4	(-63.0, -48.6)
2007	-55.2	(-62.0, -50.0)
2008	-53.0	(-62.0, -48.1)

Although the weighted means throughout all years in Region 5 are relatively consistent, the 95% and 90% confidence intervals are not consistent. The variation in the volume of the fuel procurements with a low freeze point causes differences in the confidence intervals, which become balanced when calculating the average. This results in the similar weight means shown in Table 19. Figure 44 shows each individual fuel procurement in Region 5 based on the data from 1999. For each fuel procurement, the freeze point and corresponding percent of total volume from Region 5 are shown. The weight mean freeze point is -53.9ºC and the 95% and 60% confidence intervals are shown. The large volume of fuel procurements with a low freeze point that cause the lower weight mean in 1999 can be observed in Figure 44.

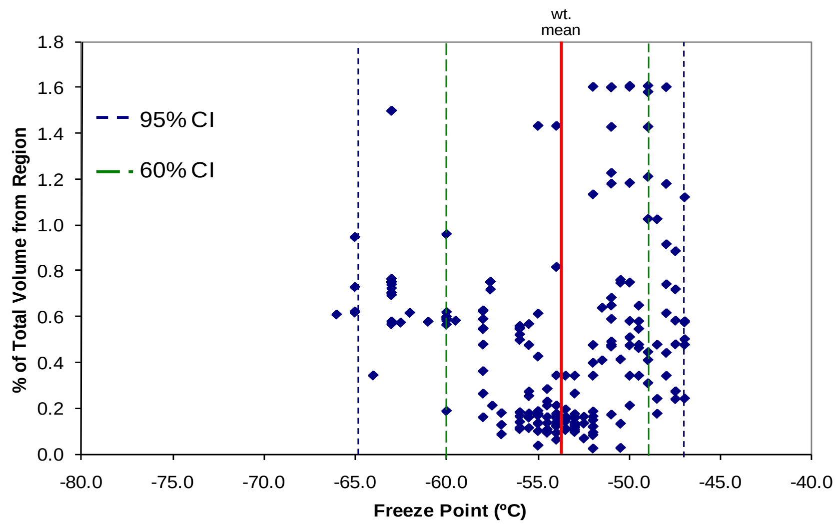

Figure 44. 1999 PQIS Freeze Point Data for Region 5.

As shown in Figure 44 by the position of the 95% confidence interval, the data is left-skewed. Due to a low volume of fuel procurements with a low freeze point and high volume of fuel procurements with a higher freeze point, the left-skewed form of the weibull distribution fits the data for Region 5. Figure 45 shows the weibull distribution curves for the years 1999-2008 from Region 5. The distribution curves for all ten years in Region 5 have consistent shapes. The curves are slightly shifted for some years due to small differences in the mean values.

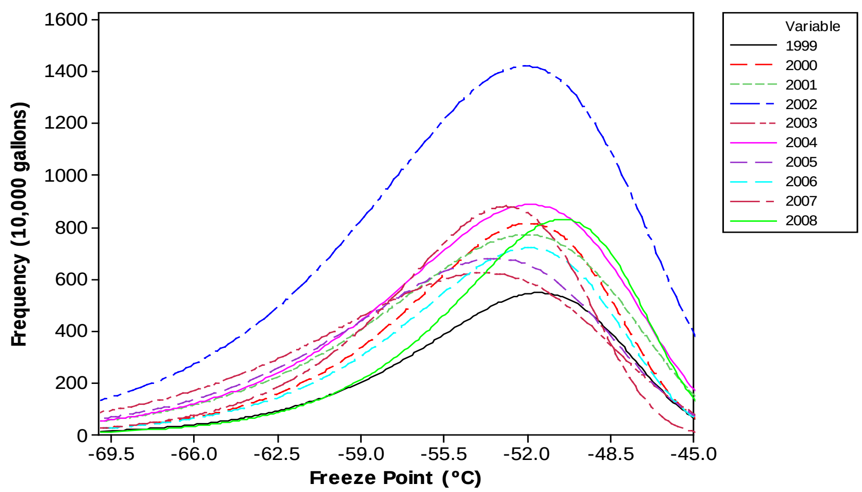

Figure 45. Histogram of the Weibull Distribution Fit Curves of the PQIS Freeze Point Data for Region 5 from 1999-2008.

The freeze point data is consistently left-skewed throughout the years 1999-2008. Some variation exists in the volume of fuel procurements with a low freeze point causing inconsistencies in the 95% and 90% confidence intervals. *Overall, the freeze point of fuel procured in Region 5 has been consistent within a range of -70.0 to -47.0ºC with a mean value of about -55.0ºC throughout the years 1999-2008.*

3.1.3.6. CONUS

Table 22 shows the calculated weight mean and 80% confidence interval of the freeze point from the 1999-2008 PQIS data for Regions 1-5 of CONUS combined. The weight mean of freeze point is consistently about -52.0ºC for all ten years. The lower bounds in the 80% confidence intervals are consistent for all ten years. Any slight variation in the weight means and upper bounds of the confidence intervals are due to differences in the volume of fuels with a low freeze point procured in each year.

Table 22. Freeze Point Statistics for CONUS.

Year	Wt mean	80% CI
1999	-51.5	(-57.0, -48.0)
2000	-52.7	(-59.8, -48.2)
2001	-53.0	(-61.3, -48.0)
2002	-53.0	(-62.0, -48.0)
2003	-53.3	(-62.0, -48.1)
2004	-51.6	(-58.0, -48.0)
2005	-52.0	(-59.0, -48.0)
2006	-52.2	(-58.1, -48.3)
2007	-52.9	(-59.8, -48.3)
2008	-51.8	(-58.5, -48.1)

Since the weighted means are consistent throughout all years in CONUS, the confidence intervals are fairly consistent. Figure 46 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the freeze point and corresponding percent of total volume from CONUS are shown. The weighted mean freeze point is -51.8ºC and the 95% and 60% confidence intervals are shown.

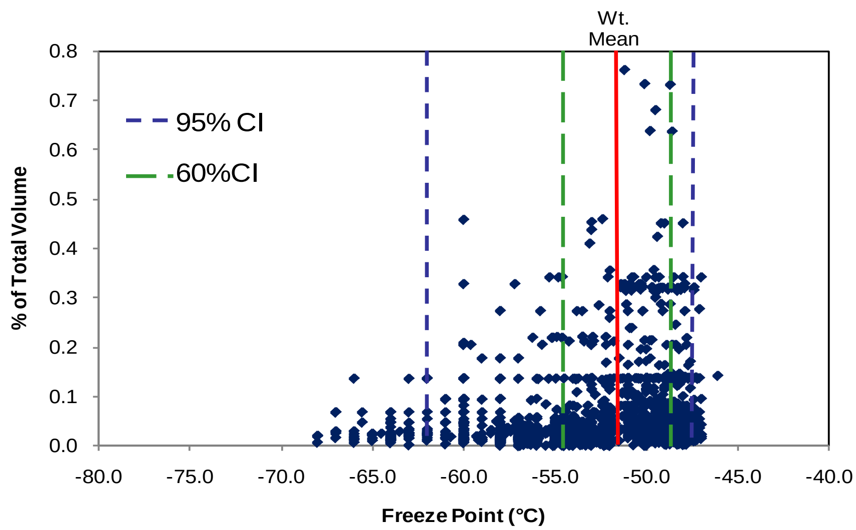

Figure 46. 2008 PQIS Freeze Point Data for Regions 2-5.

As shown in Figure 46 by the position of the 95% confidence interval, the data is left-skewed. Due to the procurement of a high volume of fuel with freeze point near the maximum specification of -47.0ºC and only a few procurements of fuel with low freeze point, the left-skewed form of the smallest extreme value distribution fits the data for CONUS. Figure 47 shows the smallest extreme value distribution curves for the years 1999-2008 from CONUS. The distribution curves for all ten years in CONUS have consistent shapes and positions.

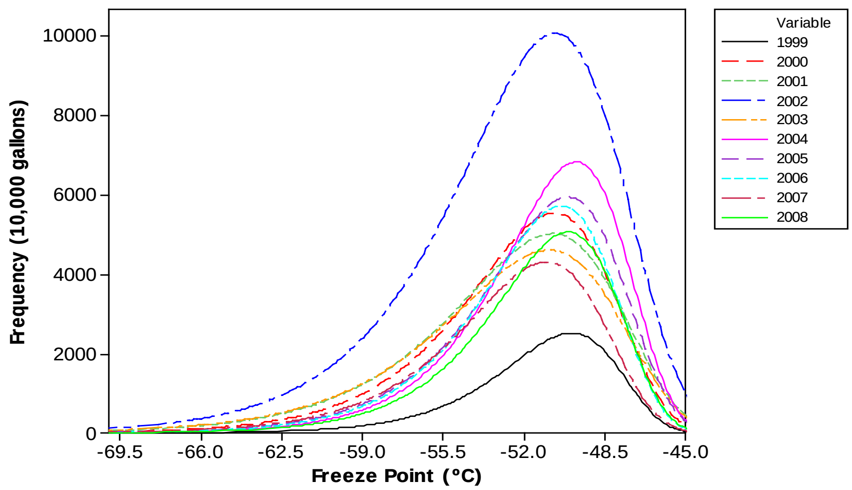

Figure 47. Histogram of the Smallest Extreme Value Distribution Fit Curves of the PQIS Freeze Point Data for CONUS from 1999-2008.

The freeze point data for CONUS combined is consistently left-skewed. The volume of fuel procured in CONUS with a low freeze point varied slightly between years resulting in the slight differences in mean values. *In general, the freeze point of fuel procured in CONUS has been consistent within a range of -65.0 to -47.0ºC with a mean value approximately -52.0ºC throughout the years 1999-2008.*

3.1.3.7. Variability of Freeze Point as a Function of Region

Table 23 shows the calculated weight mean and 80% confidence interval of the freeze point from the PQIS data for Regions 1-5 of CONUS from the combined years 1999-2008. The mean freeze point values for Regions 2 and 4 are slightly higher than the other regions at approximately -51.0ºC, while the mean values for Region 1 and 5 are the lowest at about -56.0ºC. Region 3 and CONUS combined had a mean freeze point value of about -52.0ºC. These variations are due to the differences in the range of freeze point and volume of fuel procured within each region. The 80% confidence intervals are consistent for regions with similar weight mean (Regions 2 and 4 as well as Region 3 and CONUS) due to similar volume and range of the freeze point of fuel procured. The upper bound of the confidence interval for Region 1 is lower than in other regions due to the procurement of a low volume of fuel with a freeze point near the maximum specification limit of -47.0ºC. The overlap in the confidence intervals is representative of the range of freeze point consistent within each region. However, there are distinct differences in the lower range of the freeze point and the mean values for each region. Thus the range and distribution in the freeze point of fuel procured within each region may need to be considered separately. Figure 48 shows the mean freeze point as a function of year from 1999-2008 for Regions 1-5 of CONUS. The fuel procured in Region 5 has a consistently low mean freeze point with little variation throughout all years.

Table 23. Freeze Point Statistics for All Years.

Region	Wt. Mean	80% CI
1	-57.1	(-62.0, -53.0)
2	-51.1	(-55.0, -48.0)
3	-51.9	(-58.0, -48.0)
4	-50.8	(-55.0, -48.0)
5	-55.0	(-65.0, -48.5)
CONUS	-52.5	(-60.0, -48.0)

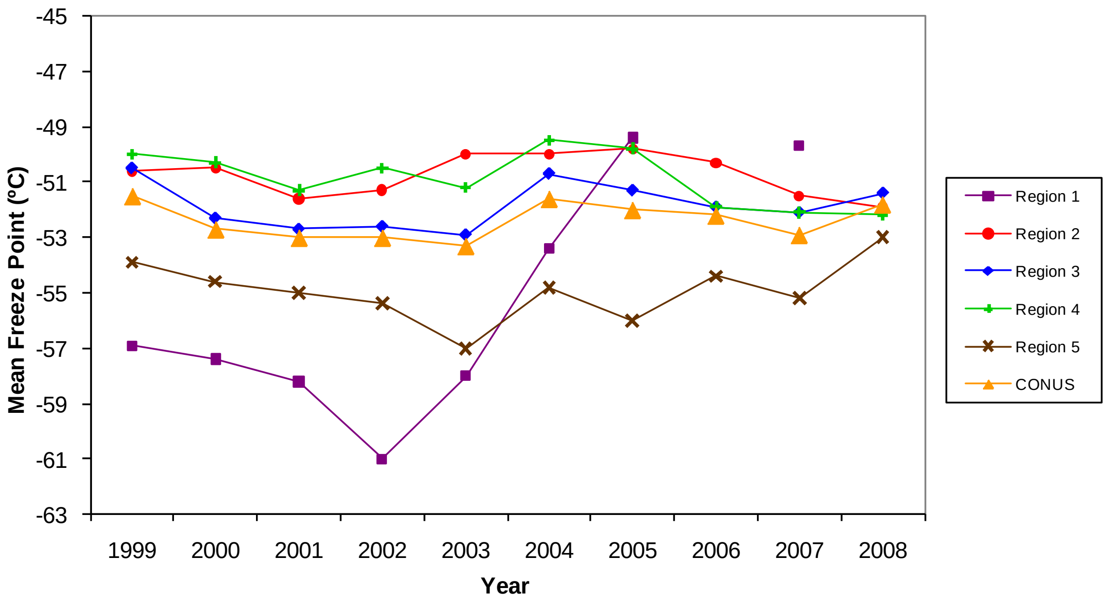

Figure 48. Weight Mean Freeze Point from Years 1999-2008 as a Function of Region and CONUS.

Figure 49 shows each individual fuel procurement in each region based on the combined data from 1999-2008. For each fuel procurement, the freeze point and corresponding percent of total volume from each region are shown. With the exception of Region 1, a large volume of the fuel procured in each region has a freeze point near the maximum specification limit of -47.0ºC. In Region 1, there was a large volume of fuel procurements with a freeze point distributed around the mean value of -56.8ºC. As shown in Figure 49, each region is consistently left-skewed. However, the skewness and minimum freeze point value within each region is not consistent throughout CONUS. *With such statistical differences between the freeze points of the fuel between most of the regions, the regions may need to be considered independently when analyzing property distributions and changes over time. If all regions of CONUS were considered as one, the freeze point of a portion of the fuel procured in Regions 2 and 4 will be underestimated and Regions 1 and 5 would be overestimated resulting in inaccurate prediction of freeze point.*

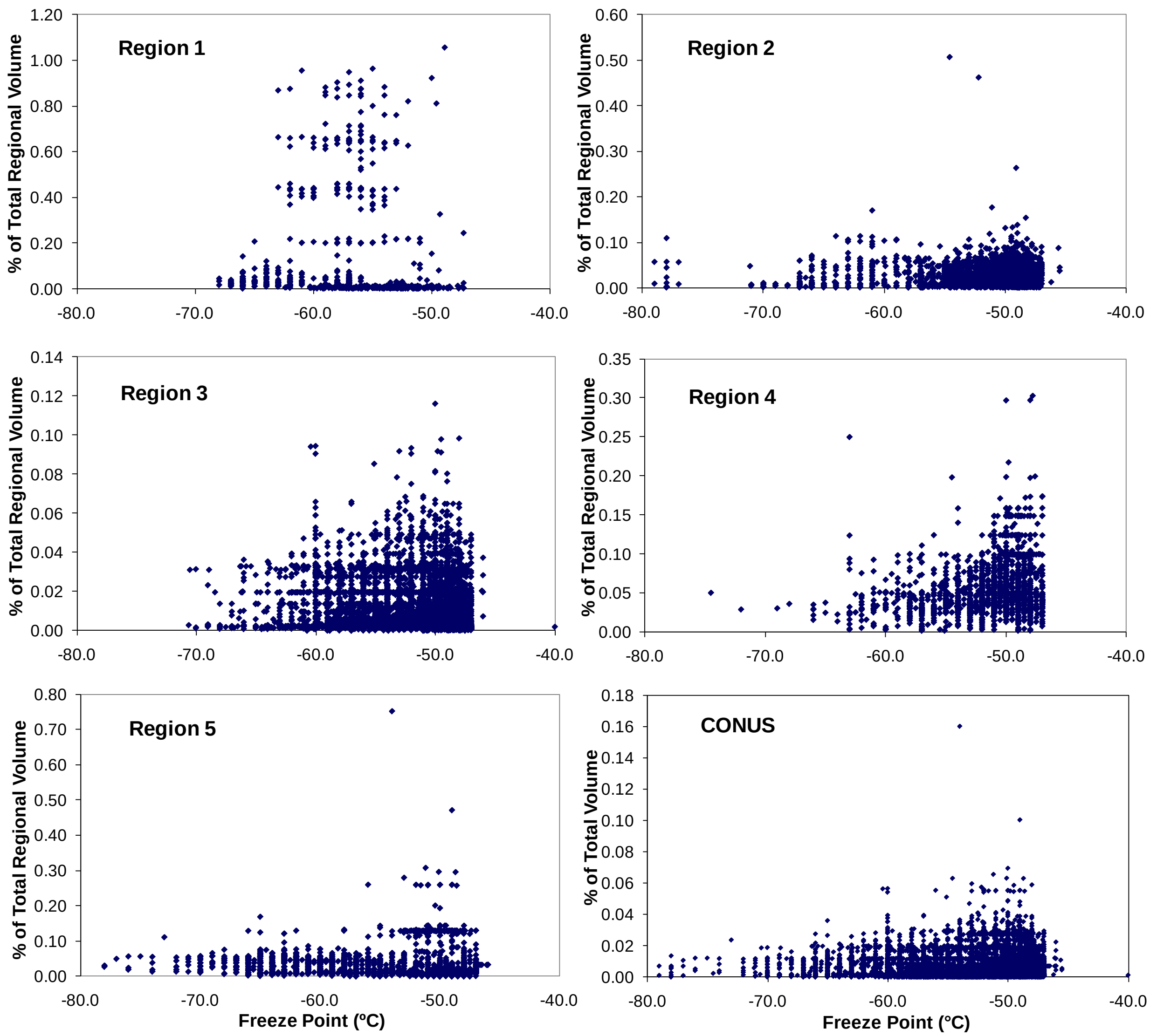

Figure 49. Combined PQIS Freeze Point Values from 1999-2008 as a Function of Region.

3.1.3.8. Summary of Freeze Point Analysis

Based on the historical freeze point data, there is no consistency in the freeze point of fuel procured throughout all years for Region 1. There is a distinct increase in the freeze point of fuel procured in the years 1999-2001 and 2003 (-58.0ºC) to the fuel procured in 2004, 2005 and 2007 (-53.4, -49.4, and -49.7ºC). However there was a distinct decrease in the freeze point in 2002 to -61.0ºC due to the procurement of a large volume of fuel with low freeze point. The range in the freeze point as well as the volume of each fuel purchase in Region 1 was not consistent for more than three consecutive years from 1999-2007. Therefore, the freeze point of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of historical trends.

In Regions 2-5, there are trends in the historical freeze point data that can be useful in predicting freeze point of JP-8 from these regions. The freeze point of fuel procured in Region 2 has been consistent within a range of -60.0 to -47.0ºC with a mean value of -50.0ºC. The freeze point of fuel procured in Region 3 has been consistent within a range of -62.0 to -47.0ºC with a mean value about -52.0ºC. The freeze point of fuel procured in Region 4 has been consistent within a range of -60.0 to -47.0ºC with a mean value of -51.0ºC. Due to the procurement of more fuel with freeze point near the maximum specification of -47.0ºC and only a few high volume procurements of fuel with low freeze point, the left-skewed form of the smallest extreme value distribution fits the data for Regions 2, 3, and 4. The freeze point of fuel procured in Region 5 has been consistent within a range of -70.0 to -47.0ºC with a mean value of approximately -55.0ºC. Due to a low volume of fuel procurements with a low freeze point and high volume of fuel procurements with a higher freeze point, the left-skewed form of the weibull distribution fits the data for Region 5.

From the analysis of the freeze point of each region it is apparent that there exists consistent trends within Regions 2-5 and CONUS combined. The freeze point of fuel procured in Region 1 has shown a wide range of variability throughout 1999-2008. The freeze point characteristics of fuel procured in CONUS has been within a range of -65.0 to -47.0ºC with a mean value of approximately -52.0ºC. The data for CONUS is left-skewed because of a number of low volume fuel procurements with a low freeze point. Although the combined analysis of CONUS was consistent, the difference between individual regions is too substantial to disregard and analyze all regions together. A summary of trends in freeze point mean statistics and 60% confidence intervals for each region and CONUS combined is shown in Table 24. With the exception of Region 1, the freeze point of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 24.

Table 24. Overall Freeze Point Statistics for Each Region and CONUS Based On the PQIS Data for 1999-2008.

Region	Mean	60% CI	80% CI
1	**	**	**
2	-50.0	-52.0 to -48.8	-53.5 to -48.0*
3	-52.0	-55.5 to -49.0	-57.0 to -48.0
4	-51.0	-53.0 to -48.5	**
5	-55.0	-62.0 to -50.0	-64.0 to -49.0
CONUS	-52.0	-56.0 to -48.7	-59.0 to -48.1*

*Consistent over last five years, allowing for future predictions.
** Not consistent for consecutive years, cannot be predicted.

Overall, based on the analysis of the freeze point of fuel procured in individual Regions 1-5 and CONUS combined, there are statistical differences in the lower range of the freeze point for each region. The prediction of the freeze point of JP-8 based on the analysis of CONUS combined would produce a statistically inaccurate estimation of the freeze point. Therefore, the predictability of the freeze point of fuel is dependent on the region of CONUS in which the fuel is procured. With respect to the impact during blending with SPK, variances in the value and distribution may not be of significant concern. Previous studies have shown that if the SPK has a similar volatility range and

high *iso*-/normal paraffin ratio, the freeze point will vary linearly with blend ratio. If the SPK has a freeze point which satisfies the -47°C specification, it is highly probable the blend will satisfy the specification requirement.

3.1.4. Statistics and Distribution for Viscosity

The MIL-DTL-83133F fuel specification requires JP-8 to have a maximum kinematic viscosity (at -20°C) of 8.0 mm^2/s. The following section analyzes the PQIS kinematic viscosity (at -20°C) data from regions 1-5 of CONUS for the years 1999-2008. The complete detailed analysis of the viscosity, the correlation of the distribution with the PQIS data, and the confidence intervals based on the PQIS data and distribution as a function of region and year is included in Appendix A. The weight mean viscosity and 80% confidence interval are listed for each year in the regions of CONUS within this discussion. The 80% confidence interval is representative of the variation in volume and/or the viscosity of fuel based on the position of the weight mean within the confidence interval and provides guidance regarding general variability in the data. During analysis, the percent of total volume of fuel procured within the region for a given year is also plotted as a function of the PQIS viscosity of the fuel. The 95% confidence interval is labeled on the figures to demonstrate the range in the value of the viscosity since a large percentage of the data falls within these intervals. The 60% confidence interval shows the focal or center range in which the value of the viscosity is likely to fall. The data from 1999 for Regions 1-5 and from 2008 for CONUS is plotted in these figures for each region since a large volume of fuel was procured during these years and the relative distribution is representative of fuel procured within a specific region.

3.1.4.1. Region 1

Table 25 shows the calculated weight mean and 80% confidence interval of the viscosity from the 1999-2005 and 2007 PQIS data for Region 1 of CONUS. No JP-8 fuel was reported as being procured in Region 1 of CONUS in 2006. The weight mean viscosity in 2000, 2001, 2005, and 2007 was approximately 4.03 mm^2/s, but lower in 1999 (3.60 mm^2/s) and consistently higher from 2002-2004. The weight mean viscosity was lower in 1999 due a number of high volume fuel procurements with a low viscosity and only a few low volume fuel procurements with high viscosity. In the years 2002-2004, there were fewer large volume fuel procurements with low viscosity than in other years resulting in a higher mean viscosity. The 80% confidence intervals are inconsistent for most years from 1999-2007. These variations are due to inconsistencies in the range of viscosity and concentration of volume at different levels of viscosity between the years.

Table 25. Viscosity Statistics for Region 1.

Year	Wt mean	80% CI
1999	3.60	(3.10, 3.96)
2000	4.05	(3.39, 5.18)
2001	4.02	(3.69, 4.60)
2002	4.37	(3.90, 5.12)
2003	4.75	(4.20, 5.30)
2004	4.81	(3.63, 6.03)
2005	4.03	(3.92, 4.12)
2007	4.02	(4.01, 4.07)

Although there is some consistency in the weight mean viscosity of some years, there is no consistency in the confidence intervals throughout all years. In Region 1, there were few fuel procurements recorded for each year. The low number of fuel procurements reported fall within a large range of volume and viscosity values. Thus the viscosity of fuel procured in Region 1 is not consistent throughout the all years. Figure 50 shows each individual fuel procurement in Region 1 based on the data from 1999. For each fuel procurement, the viscosity and corresponding percent of total volume from Region 1 are shown. The weighted mean viscosity was 3.60 mm²/s and the 95% and 60% confidence intervals are shown. The high volume of low viscosity fuel procurements resulting in the low mean viscosity can be seen in Figure 50.

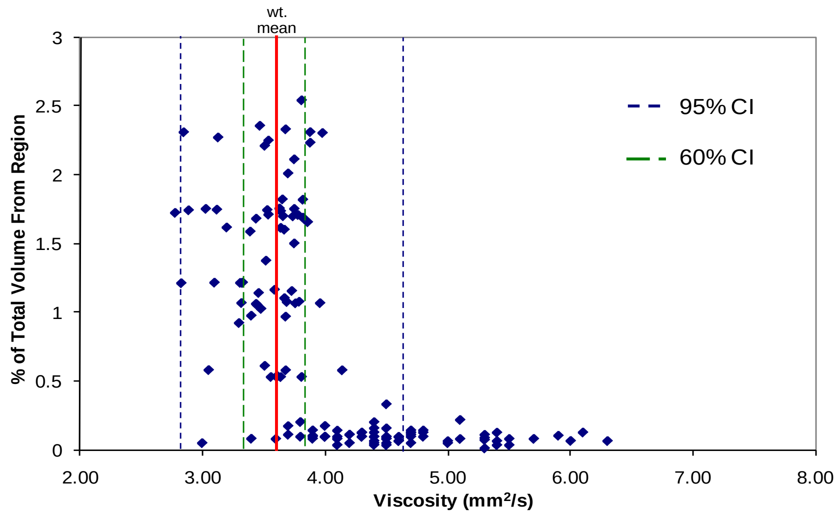

Figure 50. 1999 PQIS Viscosity Data for Region 1.

As shown in Figure 50 by the position of the 95% confidence interval, the viscosity data is right-skewed. Due to the high volume fuel procurements with low viscosity and lower volume procurements with high viscosity within each year, the right-skewed form of the loglogistic probability distribution fits the data for Region 1. Figure 51 shows the loglogistic distribution curves for the years 1999-2007 from Region 1. Since the y-axis is the volume of fuel procured for a specific viscosity, the variation in the height of the curves is due to the differing volumes of fuel procured within each year. The skewness and location of the curves are inconsistent for all years because of the variation in the range of viscosity within each year.

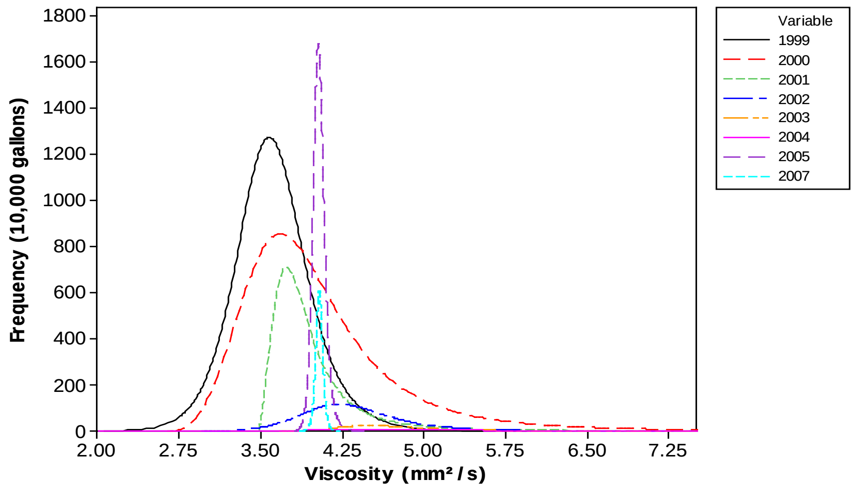

Figure 51. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Viscosity Data for Region 1 from 1999-2007.

There is a distinct increase in the viscosity of fuel procured in the years 2000, 2001, 2005, and 2007 (4.03 mm²/s) to the fuel procured in 2002-2004. However, the fuel procured in 1999 had a lower mean value (3.60 mm²/s) than all other years due to the procurement of a large volume of fuel with low viscosity during this year. The range in the viscosity as well as the volume of each fuel purchase in Region 1 is not consistent for more than three consecutive years from 1999-2007. *Therefore, the viscosity of fuel procured in Region 1 cannot be predicted with a high degree of certainty.* Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of trends for CONUS combined.

3.1.4.2. Region 2

Table 26 shows the calculated weight mean and 80% confidence interval of the viscosity from the 1999-2008 PQIS data for Region 2 of CONUS. The weight mean viscosity is consistently about 4.70 mm²/s in the years 1999-2001 and 2006-2008 and increases to about 5.00 mm²/s in the years 2002-2005. The weight mean viscosity is higher in the years 2002-2005 due to a higher volume of fuel procured with high viscosity within these years. The 80% confidence intervals are fairly consistent throughout the years. In 2001 and 2008, the lower bound of the confidence interval is less than other years due to a few high volume fuel procurements with low viscosity during the year. Also the upper bound of the confidence intervals in 2000, 2006, and 2007 are slightly lower than other years because there were very few fuel procurement with viscosity above 5.50 mm²/s during these years.

Table 26. Viscosity Statistics for Region 2.

Year	Wt mean	80% CI
1999	4.82	(4.32, 5.80)
2000	4.61	(4.27, 5.05)
2001	4.68	(3.94, 5.50)
2002	4.91	(4.20, 5.70)
2003	5.00	(4.33, 5.43)
2004	5.09	(4.25, 5.58)
2005	4.92	(4.31, 5.38)
2006	4.73	(4.26, 5.15)
2007	4.54	(4.20, 4.91)
2008	4.64	(4.13, 5.38)

Although the means are consistent for some of the years in Region 2, the 95% and 90% confidence intervals are inconsistent for most years. There is a variation in the confidence intervals because of an inconsistency in the volume of fuel procured and the range in viscosity between each year. Figure 52 shows each individual fuel procurement in Region 2 based on the data from 1999. For each fuel procurement, the viscosity and corresponding percent of total volume from Region 2 are shown. The weighted mean freeze point is 4.82 mm²/s and the 95% and 60% confidence intervals are shown.

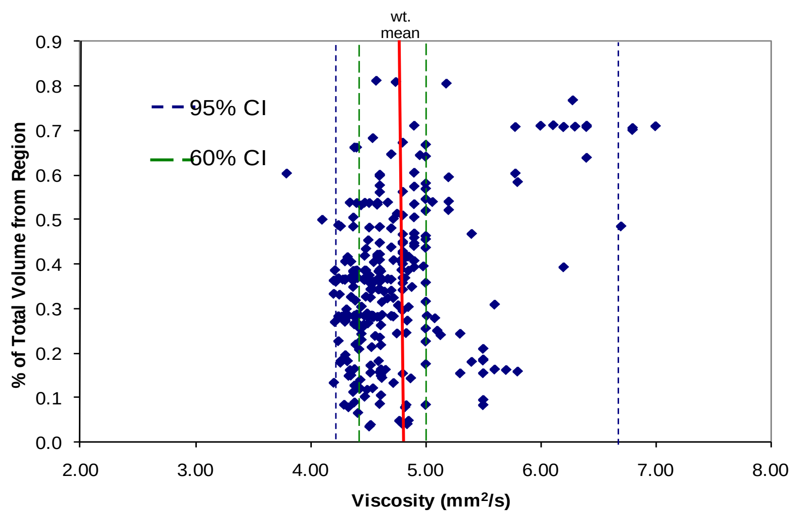

Figure 52. 1999 PQIS Viscosity Data for Region 2.

As shown in Figure 52 by the 95% confidence interval, the data is right-skewed. Due to a few high volume fuel procurements with high viscosity and a large volume of fuel within a viscosity range of 4.00 to 6.00 mm²/s, the right-skewed form of the loglogistic distribution fits the data for Region 2. Figure 53 shows the loglogistic distribution curves for the years 1999-2008 from Region 2. The distribution curves for all ten years in Region 2 have consistent shapes. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year. The curves are slightly shifted along the x-axis for some years due to variations in the weight mean.

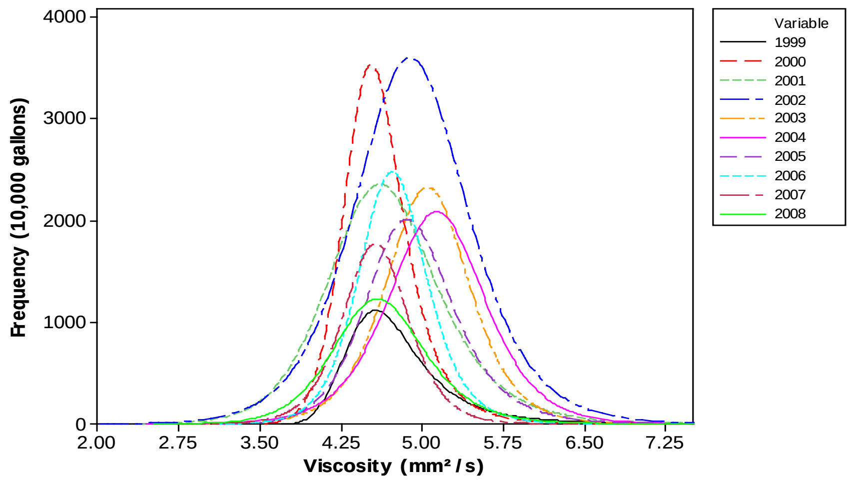

Figure 53. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Viscosity Data for Region 2 from 1999-2008.

The viscosity data is consistently right-skewed throughout 1999-2008. Some variation exists in the number and volume of fuel procurements with low and/or high viscosity causing slight differences in skewness and position of the distribution curves on the x-axis, as shown in Figure 53. *In general, the viscosity of fuel procured in Region 2 has been consistent within a range of 3.80 to 6.00 mm²/s with a mean value of 4.85 mm²/s throughout the years 1999-2008.*

3.1.4.3. Region 3

Table 27 shows the calculated weight mean and 80% confidence interval of the viscosity from the 1999-2008 PQIS data for Region 3 of CONUS. There are slight variations in the weight mean viscosity of fuel procured in Region 3 throughout the years 1999-2008. The mean viscosity is lowest in 2000 and 2001 at approximately 4.20 mm²/s and higher in the years 1999, 2002, and 2004 at 4.40 mm²/s. In 2003 and 2005-2008, the mean viscosity is the highest at approximately 4.55 mm²/s due to the procurement of a larger volume of fuel with a high viscosity in these years. The 80% confidence intervals are not consistent for most years in Region 3. This inconsistency is due to variation in the range of viscosity of the fuel procured within each year. The volume of fuel with a low or high viscosity is fairly balanced resulting in the similar weight means and varied confidence intervals as shown in Table 27.

Table 27. Viscosity Statistics for Region 3.

Year	Wt mean	80% CI
1999	4.36	(3.60, 5.20)
2000	4.19	(3.50, 4.94)
2001	4.25	(3.30, 5.30)
2002	4.39	(3.20, 5.40)
2003	4.56	(3.30, 5.50)
2004	4.42	(3.83, 5.68)
2005	4.49	(3.50, 5.50)
2006	4.55	(3.60, 5.40)
2007	4.56	(3.72, 5.40)
2008	4.48	(3.73, 5.10)

In Region 3, the confidence intervals are not consistent throughout all years. The procurement of fuel with varying volume and ranges of viscosity within each year causes the inconsistencies in the confidence intervals. Figure 54 shows each individual fuel procurement in Region 3 based on the data from 1999. For each fuel procurement, the viscosity and corresponding percent of total volume from Region 3 are shown. The weighted mean viscosity is 4.36 mm²/s and the 95% and 60% confidence intervals are shown. Figure 54 shows the wide range in viscosity of fuel procured in Region 3.

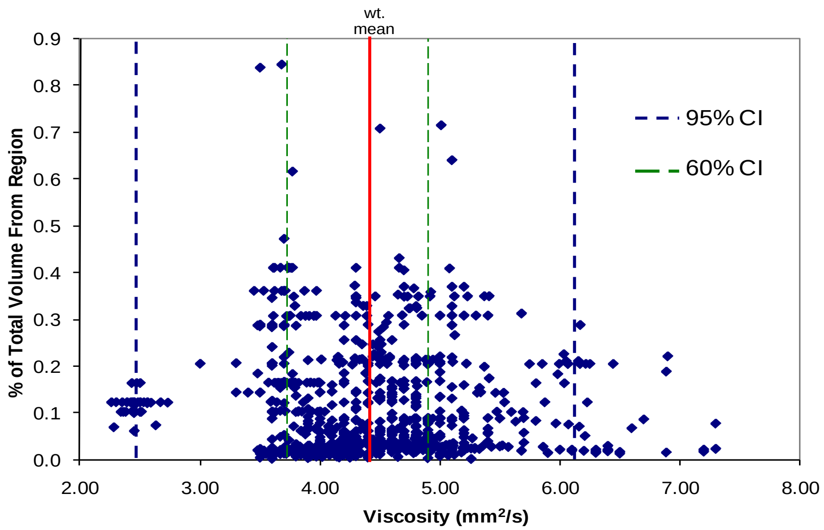

Figure 54. 1999 PQIS Viscosity Data for Region 3.

As shown in Figure 54 by the position of the confidence intervals, the data is normally distributed. Due to the even volume of fuel procured with low and high viscosity, the symmetric form of the normal distribution fits the data for Region 3. Figure 55 shows the normal distribution curves for the years 1999-2008 from Region 3. The distribution curves for all ten years in Region 3 have consistent shapes. The curves are slightly shifted for some years due to differences in the mean values. The difference in height of the curves is only caused by the varying number of gallons of fuel procured each year.

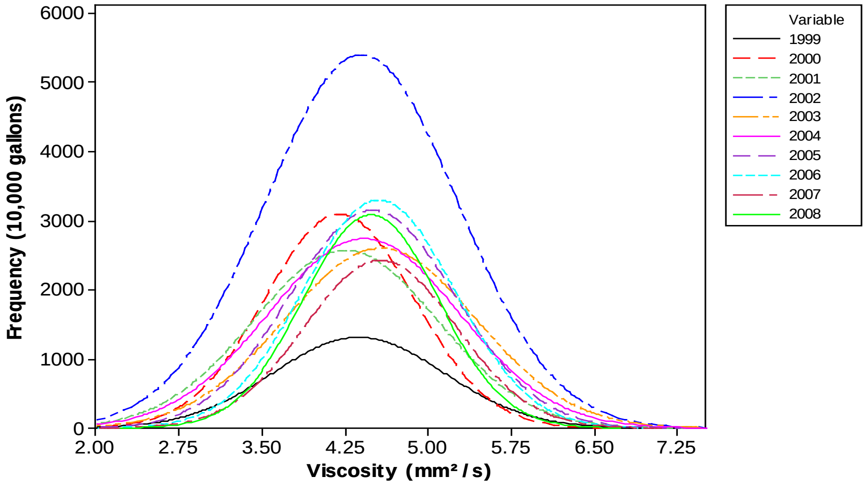

Figure 55. Histogram of the Normal Distribution Fit Curves of the PQIS Viscosity Data for Region 3 from 1999-2008.

The viscosity data is normally distributed throughout the years 1999-2008. There exists a slight variation throughout the years in the range in viscosity of fuel procured in Region 3 resulting in confidence intervals that are not consistent. *In general, the viscosity of fuel procured in Region 3 has been consistent within a range of 2.50 to 6.20 mm²/s with a mean value about 4.40 mm²/s throughout the years 1999-2008.*

3.1.4.4. Region 4

Table 28 shows the calculated weight mean and 80% confidence interval of the viscosity from the 1999-2008 PQIS data for Region 4 of CONUS. There are slight variations in the mean viscosity of fuel procured in Region 4 with the lowest value being in 1999 and 2000 at approximately 4.00 mm²/s. The mean viscosity was 4.15 mm²/s in 2001 and 2003 and slightly higher in the years 2004-2006 and 2008 at approximately 4.30 mm²/s. In the years 2002 and 2007, the mean viscosity of fuel was higher (4.54 and 4.83 mm²/s) due a few large volume fuel procurements with a viscosity higher than in any other year. With the exception of 2000, the lower bounds of the 80% confidence intervals are consistent. In 2000, there are a number of high volume fuel procurements with a low viscosity resulting in the confidence intervals to be lower than other years. Variation in the upper bounds of the confidence intervals is due to the procurement of differing volumes of fuel with a higher viscosity procured in each year.

Table 28. Viscosity Statistics for Region 4.

Year	Wt mean	80% CI
1999	4.04	(3.60, 4.60)
2000	3.91	(3.43, 4.48)
2001	4.15	(3.77, 4.70)
2002	4.54	(3.79, 5.80)
2003	4.16	(3.80, 4.85)
2004	4.28	(3.80, 4.96)
2005	4.36	(3.80, 4.93)
2006	4.38	(3.66, 5.83)
2007	4.83	(3.70, 7.00)
2008	4.39	(3.86, 5.04)

Due the variation in the volume and viscosity range of fuel procured in Region 4, the confidence intervals vary throughout most of the years in Region 4. Figure 56 shows each individual fuel procurement in Region 4 based on the data from 1999. For each fuel procurement, the viscosity and corresponding percent of total volume from Region 4 are shown. The weighted mean viscosity is 4.04 mm²/s and the 95% and 60% confidence intervals are shown. The low number of fuel procurements and variation in viscosity can be seen in Figure 56.

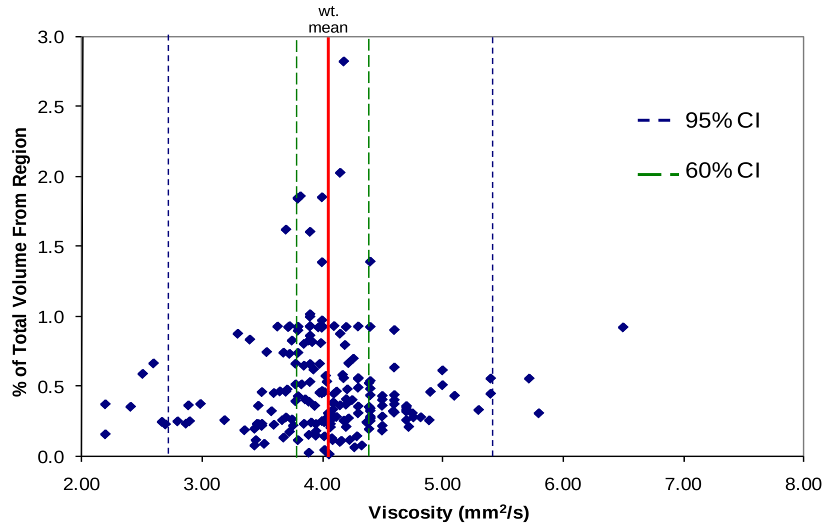

Figure 56. 1999 PQIS Viscosity Data for Region 4.

As shown by the position of the 95% confidence interval in Figure 56, the data is slightly right-skewed. Due to a few high volume fuel procurements with a high viscosity, the right-skewed form of the loglogistic distribution fits the data for Region 4. Figure 57 shows the loglogistic distribution curves for the years 1999-2008 from Region 4. With the exception of 2007, the distribution curves have a consistent shape for all years. Slight variations in the skewness and position of the curves are caused by the procurement of different volumes and ranges in viscosity in each year.

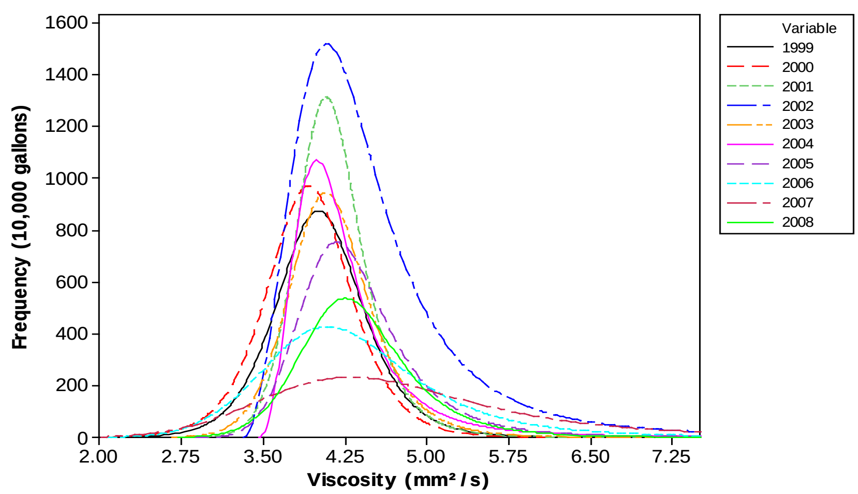

Figure 57. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Viscosity Data for Region 4 from 1999-2008.

The viscosity data was consistently right-skewed throughout the years 1999-2008. The range in viscosity as well as the volume of each fuel procurement in Region 4 varies slightly throughout the years 1999-2008. *However, the viscosity of fuel procured in Region 4 has been consistent within a range of 2.70 to 6.00 mm²/s with a mean value of 4.26 mm²/s throughout the years 1999-2008.*

3.1.4.5. Region 5

Table 29 shows the calculated weight mean and 80% confidence interval of the viscosity from the 1999-2008 PQIS data for Region 5 of CONUS. There is slight variation in the mean viscosity of fuel procured in Region 5 with the lowest being in 2005-2008 at about 4.60 mm^2/s. The mean viscosity of 5.04 mm²/s is consistent for 2001-2002 and consistently 5.19 for 1999 and 2003. In 2004, the mean viscosity is at a maximum weight mean of 5.38 mm²/s due to a larger number of high volume fuel procured with a high viscosity than any other year. The 80% confidence intervals are varied due to the procurement of fuel of differing volumes within a range of viscosity in each year.

Table 29. Viscosity Statistics for Region 5.

Year	Wt mean	80% CI
1999	5.19	(4.00, 6.30)
2000	4.88	(3.90, 6.30)
2001	5.04	(4.25, 6.30)
2002	5.04	(4.34, 6.19)
2003	5.19	(4.29, 6.33)
2004	5.38	(4.52, 6.40)
2005	4.77	(4.09, 5.72)
2006	4.69	(4.12, 5.23)
2007	4.39	(4.00, 4.78)
2008	4.54	(4.10, 5.20)

Due to the variation in the volume of the fuel procurements between each year within a consistent range of viscosity, the confidence intervals are not consistent for most years in Region 5. Figure 58 shows each individual fuel procurement in Region 5 based on the data from 1999. For each fuel procurement, the viscosity and corresponding percent of total volume from Region 5 are shown. The weighted mean viscosity is 5.19 mm²/s and the 95% and 60% confidence intervals are shown.

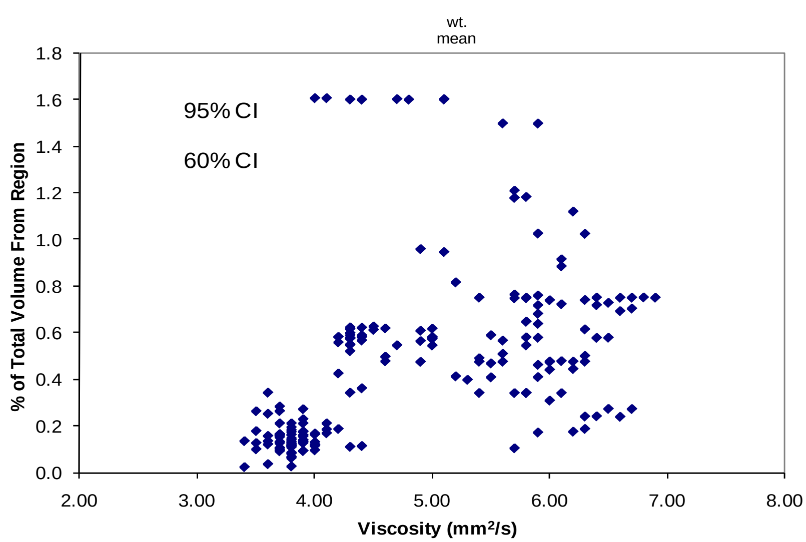

Figure 58. 1999 PQIS Viscosity Data for Region 5.

As shown in Figure 58 by the position of the 95% confidence interval, the data is slightly right-skewed. The symmetry of the confidence intervals indicates the data maintains a relatively normal shape. Due to a number of high volumes of fuel procurements with a lower viscosity and a few fuel procurements with a high viscosity, the right-skewed form of the lognormal distribution fits the data for Region 5. Figure 59 shows the lognormal distribution curves for the years 1999-2008 from Region 5. There is variation in the skewness of the distribution curves due to inconsistent volumes of fuel procured with high and/or low viscosity within each year. As expected from the variation in weight means, the position of the distribution curves are shifted on the x-axis.

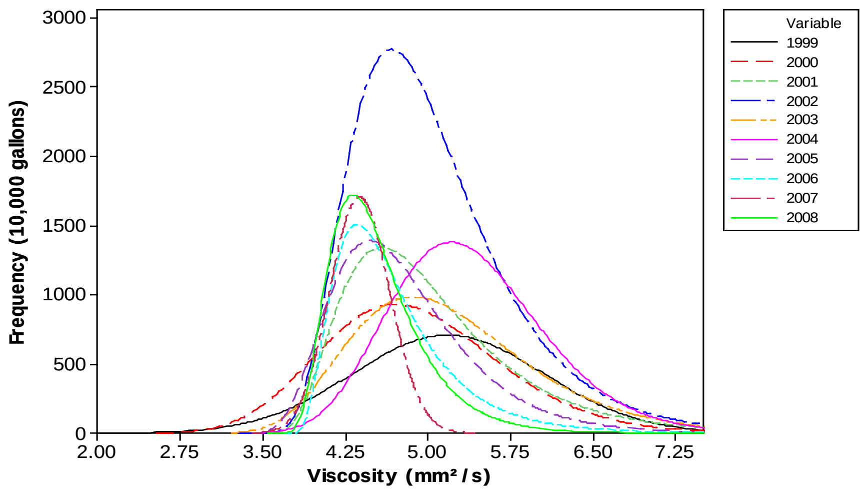

Figure 59. Histogram of the Lognormal Distribution Fit Curves of the PQIS Viscosity Data for Region 5 from 1999-2008.

The viscosity data is consistently right-skewed throughout the years 1999-2008. Some variation exists in the volume of fuel procurements with a low and/or high viscosity causing inconsistencies in the 95% and 90% confidence intervals. *In general, the viscosity of fuel procured in Region 5 has been consistent within a range of 3.70 to 6.70 mm²/s with inconsistent mean values throughout the years 1999-2008. The viscosity in the last four years has been consistently lower (4.60 mm²/s) than in previous years, allowing for the prediction of the viscosity of fuel procured in Region 5.*

3.1.4.6. CONUS

Table 30 shows the calculated weight mean and 80% confidence interval of the kinematic viscosity (at -20°C) from the 1999-2008 PQIS data for Regions 1-5 of CONUS combined. There are small variations in the weight mean viscosity of fuel procured in CONUS with a minimum weight mean of 4.36 mm²/s in 2000. Consistent weight mean viscosities were observed for 1999, 2001 and 2007-2008 (4.50 mm²/s) and for years 2002, 2005, and 2006 (4.60 mm²/s). The highest mean viscosity occurs in 2003 and 2004 at approximately 4.73 mm²/s due to a few procurements of fuel in these years with a viscosity higher than in any other year. Any variation in the 80% confidence intervals is the result of differing volumes of fuel procured in each year within a consistent range of viscosity.

Table 30. Viscosity Statistics for CONUS.

Year	Wt mean	(3.60, 5.78)
1999	4.50	(3.57, 5.11)
2000	4.36	(3.50, 5.50)
2001	4.48	(3.47, 5.68)
2002	4.61	(3.56, 5.84)
2003	4.74	(3.86, 5.94)
2004	4.72	(3.70, 5.50)
2005	4.59	(3.70, 5.36)
2006	4.59	(3.60, 5.78)
2007	4.54	(3.80, 5.17)
2008	4.50	(3.90, 5.16)

Due to variation in the volume of fuel procured within a consistent range of viscosity, the confidence intervals are not consistent for most years in CONUS. Figure 60 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the viscosity and corresponding percent of total volume from CONUS are shown. The weighted mean viscosity is 4.50 mm²/s and the 95% and 60% confidence intervals are shown.

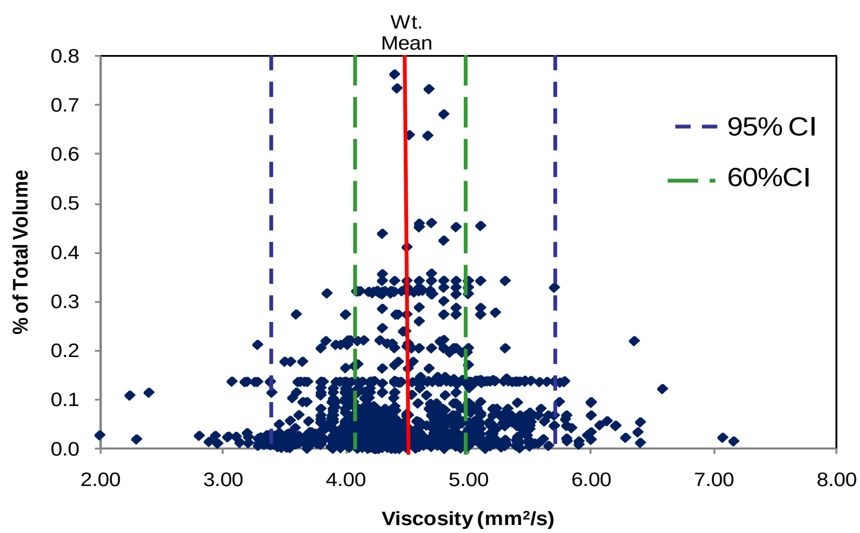

Figure 60. 2008 PQIS Viscosity Data for Regions 2-5.

As shown in Figure 60 by the position of the 95% confidence interval, the data is right-skewed. The symmetry of the confidence intervals indicates the data maintains a relatively normal shape. Due to a few high volume fuel procurements with a high viscosity, the right-skewed form of the lognormal distribution fits the data for CONUS. Figure 61 shows the lognormal distribution curves for the years 1999-2008 from CONUS. The distribution curves for all ten years in CONUS have consistent shapes. The position of the distribution curves are shifted for some years due to variation in the mean values.

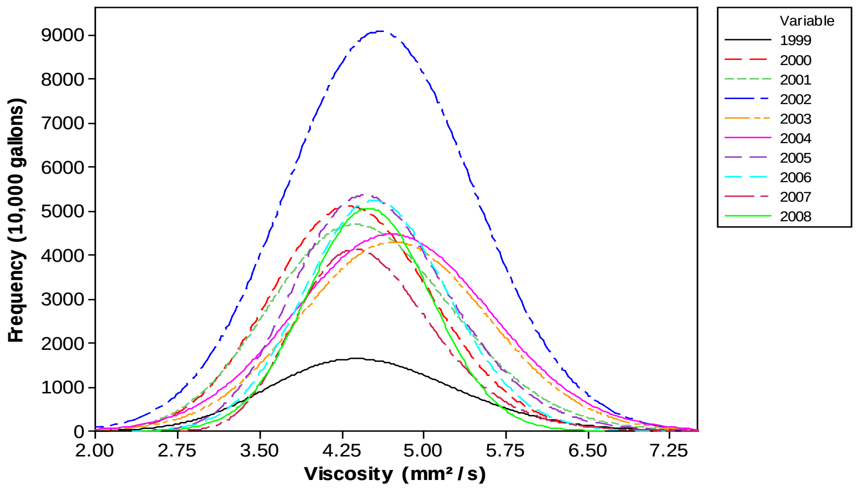

Figure 61. Histogram of the Lognormal Distribution Fit Curves of the PQIS Viscosity Data for CONUS from 1999-2008.

The viscosity data for CONUS combined is consistently right-skewed. The volume of fuel procured in CONUS within a consistent range of viscosity varied slightly between years resulting in the differences in mean values and confidence intervals. *In general, the viscosity of fuel procured in CONUS has been consistent within a range of 2.70 to 6.40 mm²/s with a mean value about 4.59 mm²/s throughout the years 1999-2008.*

3.1.4.7. Variability of Viscosity as a Function of Region

Table 31 shows the calculated weight mean and 80% confidence interval of the viscosity from the PQIS data for Regions 1-5 of CONUS from the combined years 1999-2008. There is statistical variation in the mean viscosity of fuel procured within Regions 1-5 and CONUS combined. These variations are due to the differences in the range of viscosity and volume of fuel procured within each region. The 80% confidence intervals are also inconsistent for Regions 1-5 and CONUS. The overlap in the confidence intervals is representative of the range of viscosity consistent within each region. However, there are distinct differences in the lower and upper limits of the range in viscosity and the mean values for each region. Thus the range and distribution in the viscosity of fuel procured within each region may need to be considered separately. Figure 62 shows the mean viscosity as a function of years from 1999-2008 for Regions 1-5 of CONUS. The fuel procured in Region 5 has a consistently high mean viscosity throughout all years.

Table 31. Viscosity Statistics for All Years.

Region	Wt. Mean	80% CI
1	3.91	(3.33, 4.80)
2	4.81	(4.21, 5.43)
3	4.42	(3.50, 5.33)
4	4.28	(3.71, 5.03)
5	4.96	(4.20, 6.16)
CONUS	4.56	(3.65, 5.52)

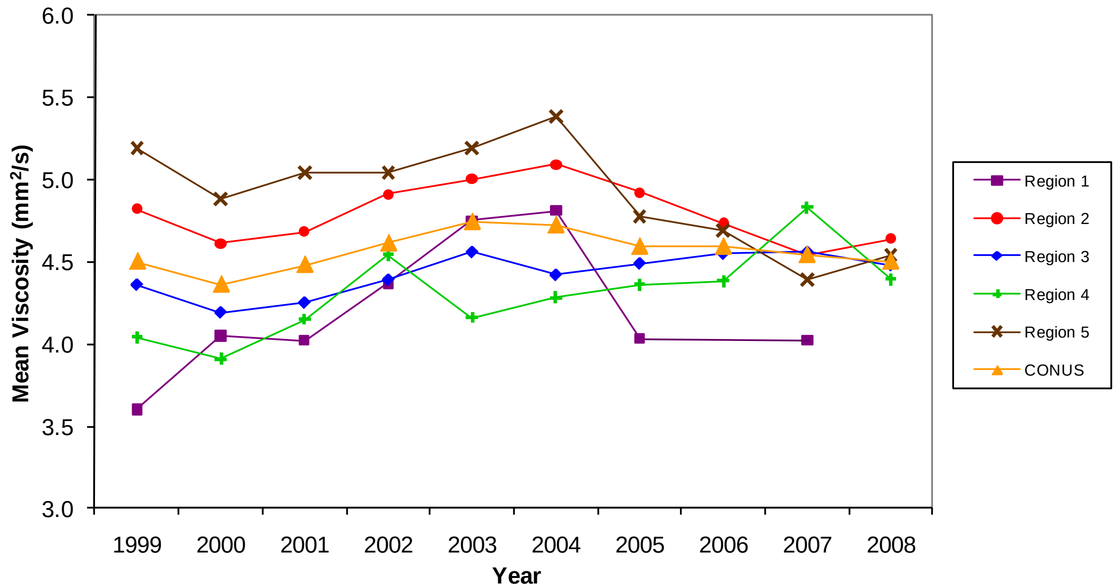

Figure 62. Weight Mean Viscosity from Years 1999-2008 as a Function of Region and CONUS.

Figure 63 shows each individual fuel procurement in each region based on the combined data from 1999-2008. For each fuel procurement, the viscosity and corresponding percent of total volume from each region are shown. The level of viscosity in which the largest volume of fuel is found to have is not consistent for any two regions. As shown in Figure 63, each region is consistently right-skewed with the exception of Region 3, which is normally distributed. However, the range and skewness of the distributions for Regions 1, 2, 4, and 5 also vary. With such statistical differences between the viscosities of the fuel between most of the regions, the regions may need to be considered independently when analyzing property distributions and changes over time. If all regions of CONUS were considered as one, the viscosity of a portion of the fuel procured in Regions 5 will be underestimated and Regions 1, 3 and 4 would be overestimated resulting in inaccurate prediction of viscosity.

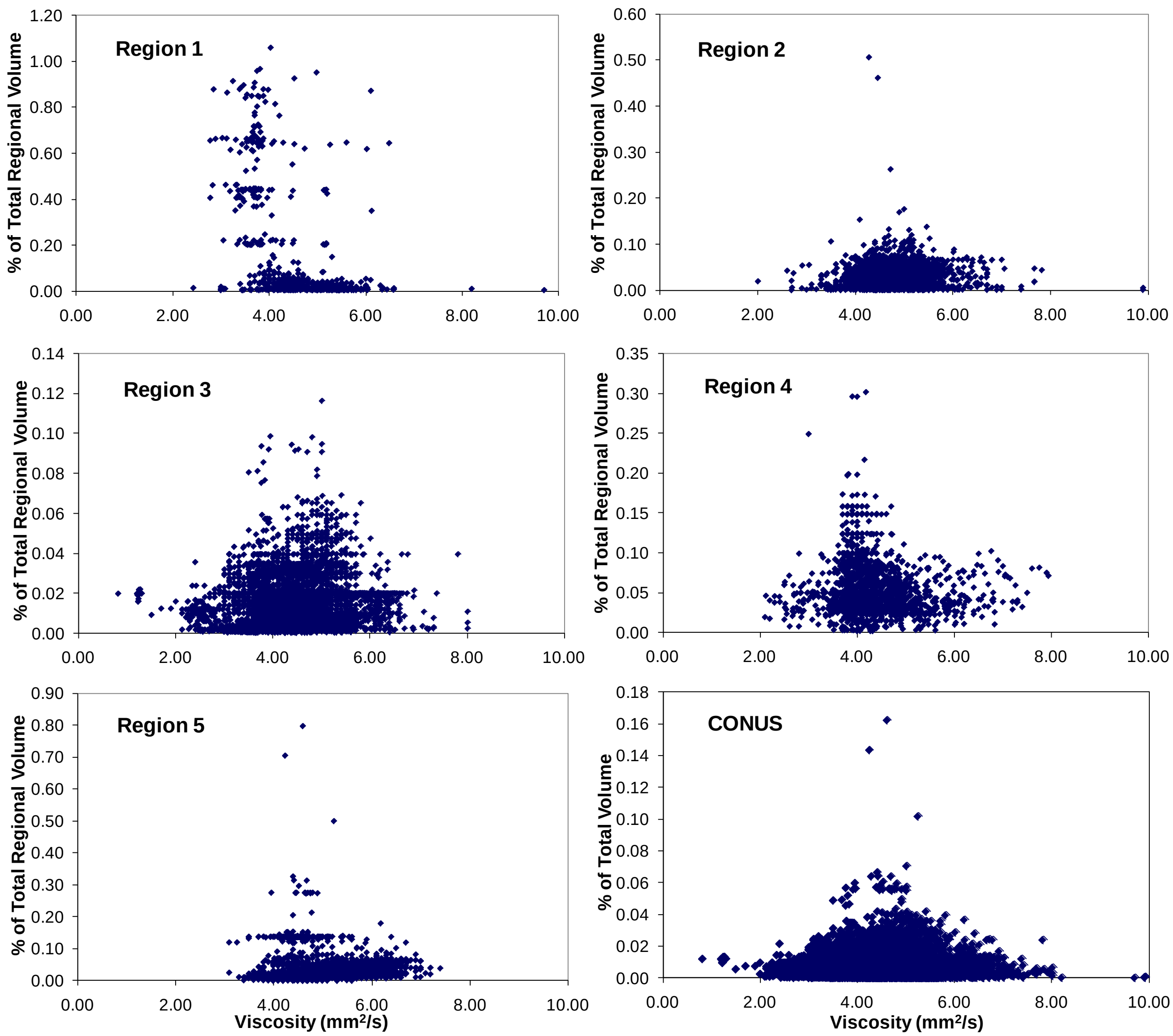

Figure 63. Combined PQIS Viscosity Values from 1999-2008 as a Function of Region.

3.1.4.8. Summary of Kinematic Viscosity Analysis

Based on the historical viscosity data, there is no consistency in the viscosity of fuel procured throughout all years for Region 1. There is a distinct increase in the viscosity of fuel procured in the years 2000, 2001, 2005 and 2007 (4.03 mm^2/s) compared to the fuel procured in 2002-2004. However, the fuel procured in 1999 had a lower mean value (3.60 mm^2/s) than all other years due to the procurement of a large volume of fuel with low viscosity during this year. The range in the viscosity as well as the volume of each fuel procurement in Region 1 was not consistent for more than three consecutive years from 1999-2007. Therefore, the viscosity of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of historical trends.

In Regions 2-5, there is a trend in the historical kinematic viscosity data that can be useful in predicting property trends from these regions. The viscosity of fuel procured in Region

2 has been consistent within a range of 3.80-6.00 mm²/s with a mean value of 4.85 mm²/s. The viscosity of fuel procured in Region 4 has been consistent within a range of 2.70 to 6.00 mm²/s with a mean value of 4.26 mm²/s. Due to a few high volume fuel procurements with a high viscosity, the right-skewed form of the loglogistic distribution fits the data for Regions 2 and 4. The viscosity of fuel procured in Region 3 has been consistent within a range of 2.50 to 6.20 mm²/s with a mean value about 4.40 mm²/s. The data for Region is normally distributed because the viscosity of the fuel procured is symmetrically distributed about the mean viscosity. The viscosity of fuel procured in Region 5 has been consistent within a range of 3.70 to 6.70 mm²/s with slightly inconsistent mean values. The mean viscosity in the years 2005-2008 has been consistently lower, about 4.60 mm^2/s, than in previous years. This recent consistency allows for prediction of the viscosity of fuel procured in Region 5. Due to a number of high volumes of fuel procurements with a lower viscosity and a few fuel procurements with a high viscosity, the right-skewed form of the lognormal distribution fits the data for Region 5.

From the analysis of the kinematic viscosity (at -20°C) of each region it is apparent that there exists consistent trends within Regions 2-5 and CONUS combined. The viscosity of fuel procured in Region 1 has shown a wide range of variability throughout 1999-2008. The viscosity of fuel procured in CONUS has been consistent within a range of 2.70 to 6.40 mm²/s with a mean value of approximately 4.59 mm²/s. The data for CONUS is right-skewed because of a few high volume fuel procurements with a high viscosity. Although the combined analysis of CONUS was consistent, the difference between regions is too substantial to disregard and analyze all regions together. A summary of trends in viscosity mean statistics and 60% confidence intervals for each region and CONUS combined is shown in Table 32. With the exception of Region 1, the viscosity of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 32.

Table 32. Overall Viscosity Statistics for Each Region and CONUS Based on the PQIS Data for 1999-2008.

Region	Mean	60% CI
1	**	**
2	4.85	4.45 – 5.10
3	4.40	3.80 – 5.00
4	4.26	3.85 – 4.60
5	4.60*	4.20 – 5.00
CONUS	4.59	3.95 – 5.10

* Consistent over last four years, allowing for future predictions

** Not consistent for consecutive years, cannot be predicted

Overall, based on the analysis of the viscosity of fuel procured in individual Regions 1-5 and CONUS combined, there are statistical differences in the mean value (approximately ±0.5) and range of viscosity. The prediction of the viscosity of fuel based on the analysis of CONUS combined would produce a statistically inaccurate estimation of the viscosity. Therefore, the predictability of the viscosity of fuel is dependent on the region of CONUS in which the fuel is procured. However, the weight means and confidence intervals are well within the specification range of 8.00 mm²/s.

3.1.5. Statistics and Distribution of Heat of Combustion

The MIL-DTL-83133F fuel specification requires that JP-8 has a minimum measured heat of combustion on a mass basis of 42.80 MJ/kg. The following section analyzes the PQIS heat of combustion data from regions 1-5 of CONUS for the years 1999-2008. The complete detailed analysis of the heat of combustion, the correlation of the distribution with the PQIS data, and the confidence intervals based on the PQIS data and distribution as a function of region and year is included in Appendix A. The weight mean heat of combustion and 80% confidence interval are listed for each year in the regions of CONUS within this discussion. The 80% confidence interval is representative of the variation in volume and/or the heat of combustion of fuel based on the position of the weight mean within the confidence interval and provides guidance regarding general variability in the data. During analysis, the percent of total volume of fuel procured within the region for a given year is also plotted as a function of the PQIS heat of combustion of the fuel. The 95% confidence interval is labeled on the figures to demonstrate the range in the value of the heat of combustion since a large percentage of the data falls within these intervals. The 60% confidence interval shows the focal or center range in which the value of the heat of combustion is likely to fall. The data from 1999 for Regions 1-5 and from 2008 for CONUS is plotted in these figures for each region since a large volume of fuel was procured during these years and the relative distribution is representative of fuel procured within a specific region.

3.1.5.1. Region 1

Table 33 shows the calculated weight mean and 80% confidence interval of the heat of combustion from the 1999-2005 and 2007 PQIS data for Region 1 of CONUS. No JP-8 fuel was reported as being procured in Region 1 of CONUS in 2006. The weight mean heat of combustion is consistently about 43.25 MJ/kg for most years and only slightly lower at about 43.07 MJ/kg for the years 2002-2004. The weight mean is lower in these years because there were a few large volume fuel procurements with a lower heat of combustion than in other years. The 80% confidence intervals are fairly consistent for all years, with the exception of 2004.

Table 33. Heat of Combustion Statistics for Region 1.

Year	Wt mean	80% CI
1999	43.23	(43.20, 43.30)
2000	43.20	(43.10, 43.30)
2001	43.19	(43.10, 43.30)
2002	43.05	(43.00, 43.10)
2003	43.06	(43.00, 43.12)
2004	43.11	(42.96, 43.37)
2005	43.27	(43.24, 43.29)
2007	43.29	(43.27, 43.30)

In 2004, there were large volume fuel procurements with heat of combustion below the minimum specification limit of 42.8 MJ/kg and one large fuel procurement with a heat of combustion above 49.00 MJ/kg. Due to these low and high values, the 95% and 90% confidence interval for 2004 contain a large range of values than other years. Figure 64 shows each individual fuel procurement in Region 1 based on the data from 2001. For each fuel procurement, the heat of combustion and corresponding percent of total volume from Region 1 are shown. The weighted mean heat of combustion was 43.19 MJ/kg and the 95% and 60% confidence intervals are shown. The low number of fuel procurements and small range of values for heat of combustion can be observed in Figure 64.

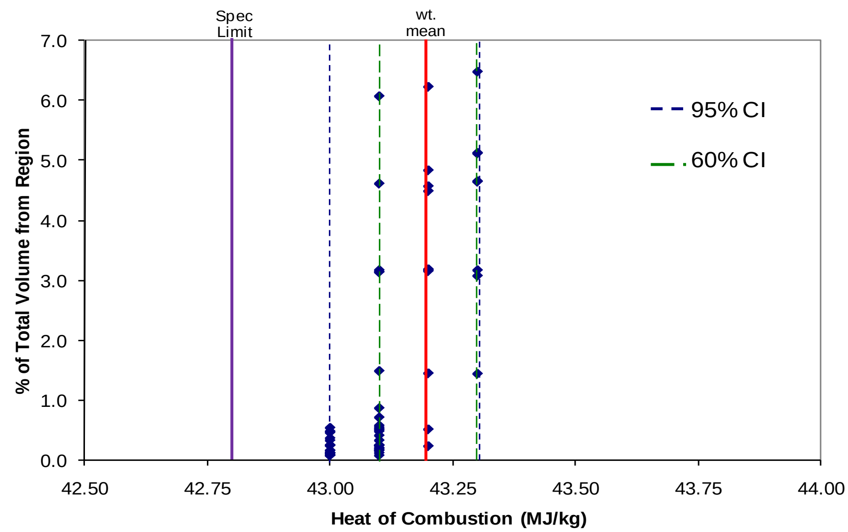

Figure 64. 2001 PQIS Heat of Combustion Data for Region 1.

As shown in Figure 54 by the position of the 95% confidence interval, the heat of combustion data is left-skewed. Due to the large volume fuel procurements with a high heat of combustion and a few small volume procurements with a slightly lower heat of combustion, the left-skewed form of the weibull probability distribution fits the data for Region 1. Figure 65 shows the weibull distribution curves for the years 1999-2007 from Region 1. Since the y-axis is the volume of fuel procured for a specific heat of combustion, the variation in the height of the curves is due to the differing volumes of fuel procured within each year. The shapes of the curves vary for some years due to the low volume of fuel procured within most of the years in Region 1.

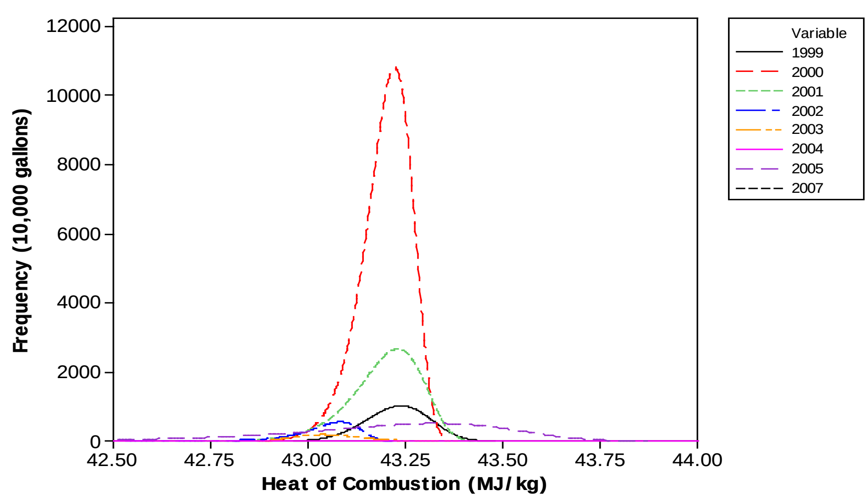

Figure 65. Histogram of the Weibull Distribution Fit Curves of the PQIS Heat of Combustion Data for Region 1 from 1999-2007.

There was a slight decrease in the mean heat of combustion of 43.25 MJ/kg in 1999-2001 and 43.07 MJ/kg in 2002-2004. However, the confidence intervals overlap within these years, indicating a reasonable probability for similar values. This variance is not a significant difference in the real-life application of the heat of combustion of JP-8 fuel. *Therefore, in general, the heat of combustion of fuel procured in Region 1 has been consistent within a range of 43.00 to 43.30 MJ/kg with a mean value of approximately 43.25 MJ/kg throughout the years 1999-2007.*

3.1.5.2. Region 2

Table 34 shows the calculated weight mean and 80% confidence interval of the heat of combustion from the 1999-2008 PQIS data for Region 2 of CONUS. The weight mean heat of combustion slightly increases from 43.25 MJ/kg in the years 1999-2002 to 43.30 MJ/kg in 2003-2008. The 80% confidence intervals are relatively consistent for all ten years. There is a slight variation in the lower bounds of the confidence intervals due to differing volumes of fuel procured with a low heat of combustion.

Table 34. Heat of Combustion Statistics for Region 2.

Year	Wt mean	80% CI
1999	43.24	(43.04, 43.33)
2000	43.27	(43.21, 43.32)
2001	43.25	(43.06, 43.34)
2002	43.25	(43.07, 43.36)
2003	43.28	(43.16, 43.34)
2004	43.28	(43.13, 43.40)
2005	43.29	(43.24, 43.44)
2006	43.30	(43.22, 43.36)
2007	43.29	(43.22, 43.34)
2008	43.31	(43.25, 43.37)

Figure 66 shows each individual fuel procurement in Region 2 based on the data from 2001. For each fuel procurement, the heat of combustion and corresponding percent of total volume from Region 2 are shown. The weighted mean freeze point is 43.25 MJ/kg and the 95% and 60% confidence intervals are shown.

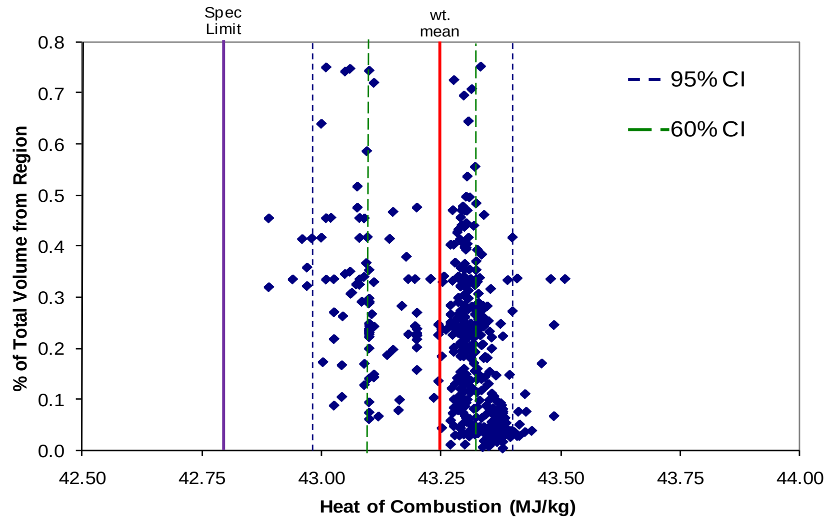

Figure 66. 2001 PQIS Heat of Combustion Data for Region 2.

As shown in Figure 38 by the confidence intervals, the data is slightly left-skewed. Due to a few fuel procurements with a low heat of combustion in each year, the left-skewed form of the weibull distribution fits the data for Region 2. Figure 67 shows the distribution curves for the years 1999-2008. The distribution curves for all ten years in Region 2 have consistent shapes with slight variations in the skewness due to differences in the volume of fuel procured with a low heat of combustion. The difference in height of the curves is only caused by the differing number of gallons of fuel procured.

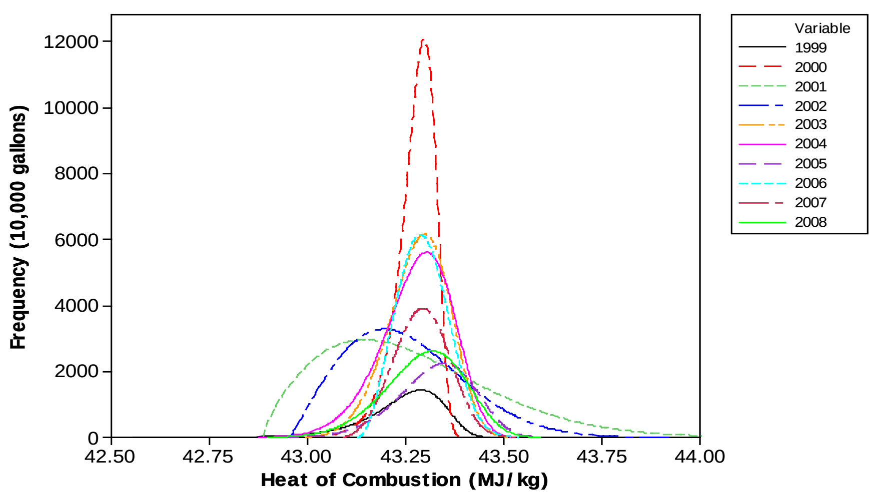

Figure 67. Histogram of the Weibull Distribution Fit Curves of the PQIS Heat of Combustion Data for Region 2 from 1999-2008.

The heat of combustion data is consistently left-skewed throughout the years 1999-2008. Some variation exists in the number and volume of fuel procurements with low heat of combustion causing slight differences in skewness and position of the distribution curves. *In general, the heat of combustion of fuel procured in Region 2 has been consistent within a range of 43.00 to 43.45 MJ/kg with a mean value of 43.30 MJ/kg throughout the last six years.*

3.1.5.3. Region 3

Table 35 shows the calculated weight mean and 80% confidence interval of the heat of combustion from the 1999-2008 PQIS data for Region 3 of CONUS. The weight mean heat of combustion is consistently about 43.20 MJ/kg. The 80% confidence intervals are within a consistent range for all years in Region 3. Any slight variation in the mean heat of combustion and 80% confidence intervals are due to the procurement of fuel with a significantly high and/or low heat of combustion during some years.

Table 35. Heat of Combustion Statistics for Region 3.

Year	Wt mean	80% CI
1999	43.27	(43.11, 43.40)
2000	43.21	(43.10, 43.32)
2001	43.22	(43.10, 43.40)
2002	43.19	(43.10, 43.40)
2003	43.21	(43.10, 43.40)
2004	43.26	(43.10, 43.36)
2005	43.25	(43.10, 43.40)
2006	43.23	(43.10, 43.40)
2007	43.23	(43.10, 43.40)
2008	43.23	(43.10, 43.40)

Figure 68 shows each individual fuel procurement in Region 3 based on the data from 2001. For each fuel procurement, the heat of combustion and corresponding percent of total volume from Region 3 are shown. The weighted mean heat of combustion is 43.22 MJ/kg and the 95% and 60% confidence intervals are shown. Figure 68 shows the few fuel procurements with a low heat of combustion that cause the slight variation in weighted mean between the years

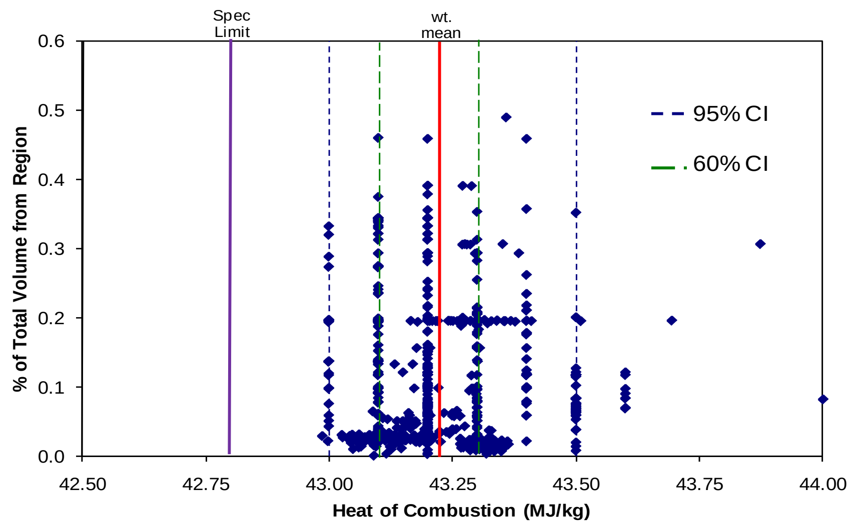

Figure 68. 2001 Heat of Combustion Data for Region 3.

As shown in Figure 68, the data is right-skewed. Due to the low volume procurement of fuel with a high heat of combustion, the right-skewed form of the loglogistic distribution fits the data for Region 3. Figure 69 shows the distribution curves for the years 1999-2008. The distribution curves for Region 3 have consistent shapes and position along the x-axis due to a consistent mean heat of combustion.

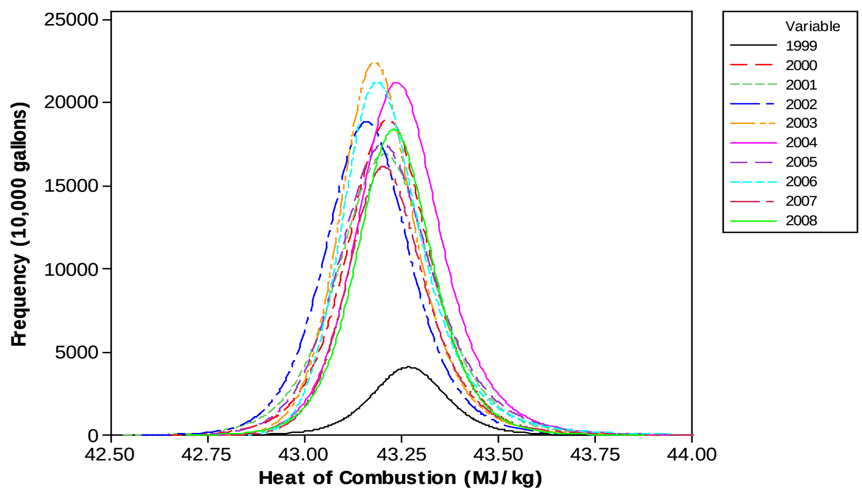

Figure 69. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Heat of Combustion Data for Region 3 from 1999-2008.

The heat of combustion data is consistently right-skewed throughout the years 1999-2008. There exists a slight variation throughout the years in the volume of fuel procured in Region 3 with a low and/or high heat of combustion. *In general, the heat of combustion of fuel procured in Region 3 has been consistent within a range of 43.00 to 43.50 MJ/kg with a mean value of approximately 43.20 MJ/kg throughout the years 1999-2008.*

3.1.5.4. Region 4

Table 36 shows the calculated weight mean and 80% confidence interval of the heat of combustion from the 1999-2008 PQIS data for Region 4 of CONUS. All years have a consistent weight mean heat of combustion of approximately 43.25 MJ/kg. In Region 4, there are a low number of fuel procurements and some variation in the number and volume of fuel procured with a low and/or high heat of combustion between years. This variation causes the slight difference in weighted means and the 80% confidence intervals as shown in Table 36.

Table 36. Heat of Combustion Statistics for Region 4.

Year	Wt mean	80% CI
1999	43.27	(43.20, 43.36)
2000	43.31	(43.19, 43.42)
2001	43.32	(43.16, 43.80)
2002	43.28	(43.10, 43.80)
2003	43.21	(43.10, 43.30)
2004	43.22	(43.14, 43.30)
2005	43.27	(43.13, 43.35)
2006	43.25	(43.10, 43.30)
2007	43.24	(43.10, 43.30)
2008	43.24	(43.13, 43.34)

The lower bounds of the confidence intervals are fairly consistent for all years with the exception of 1999 and 2000. In these years, there was a lower volume of fuel procured with a low heat of combustion resulting in higher lower bounds than other years. The upper bounds of the confidence intervals in the years 2001-2002 and 2005-2006 are higher than other years due to the procurement of a large volume of fuel with a high heat of combustion. Figure 70 shows each individual fuel procurement in Region 4 based on the data from 2001. For each fuel procurement, the heat of combustion and corresponding percent of total volume from Region 4 are shown. The weighted mean heat of combustion is 43.32 MJ/kg and the 95% and 60% confidence intervals are shown. The large volume of fuel with a high heat of combustion which increases the mean heat of combustion can be seen in Figure 70.

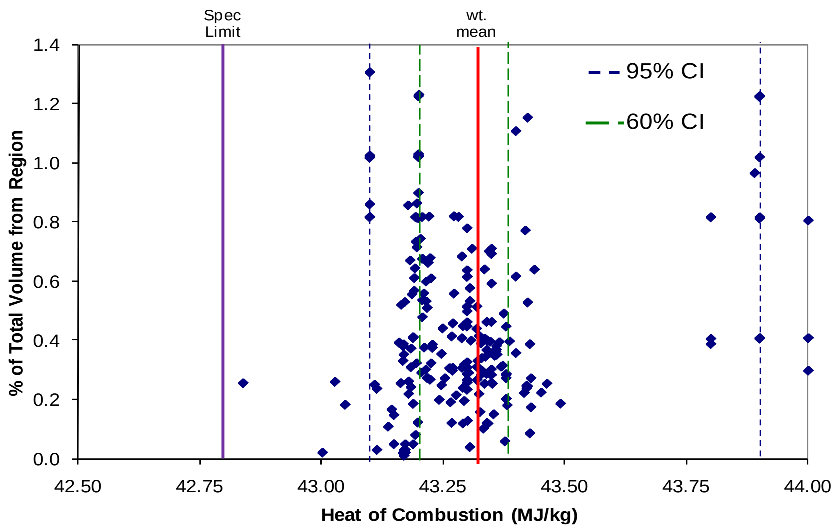

Figure 70. 2001 PQIS Heat of Combustion Data for Region 4.

As shown by the position of the 95% confidence interval in Figure 70, the data is right-skewed. Due to a few high volume fuel procurements with a high heat of combustion, the right-skewed form of the loglogistic distribution fits the data for Region 4. Figure 71 shows the distribution curves for the years 1999-2008. The distribution curves have a consistent shape for all years. Slight variations in the skewness and position of the curves are caused by the procurement of different volumes of fuel with a low and/or high heat of combustion in each year.

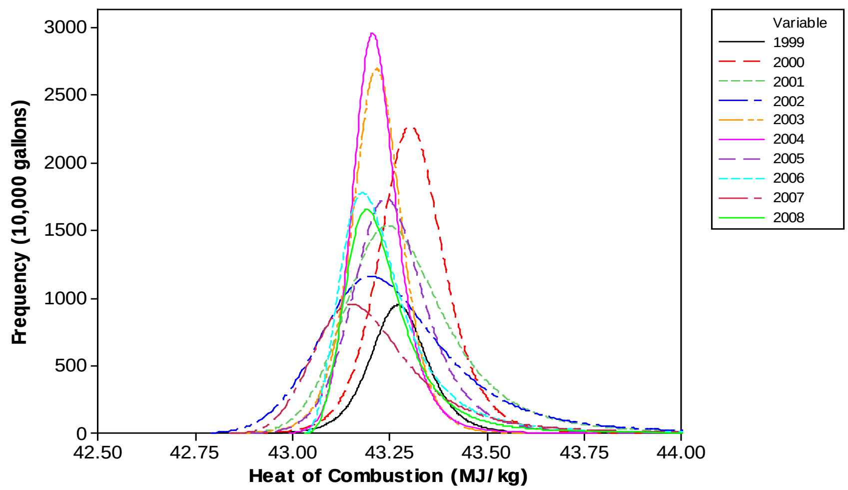

Figure 71. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Heat of Combustion Data for Region 4 from 1999-2008.

The heat of combustion data was consistently right-skewed throughout the years 1999-2008. The procurement and volume of fuel with low and/or high heat of combustion was not consistent in the years 1999-2008. The range in heat of combustion as well as the volume of each fuel procurement in Region 4 varies slightly throughout all years. *However, the heat of combustion of fuel procured in Region 4 has been consistent within a range of 43.00 to 43.80 MJ/kg with a mean value of approximately 43.25 MJ/kg throughout the years 1999-2008.*

3.1.5.5. Region 5

Table 37 shows the calculated weight mean and 80% confidence interval of the heat of combustion from the 1999-2008 PQIS data for Region 5 of CONUS. With the exception of 2002, the weight mean heat of combustion is consistently about 43.10 MJ/kg. The 80% confidence intervals are also fairly consistent throughout all years, except for the upper bound of the 80% confidence interval in 2002. In 2002, the was a large volume of fuel procured with a high heat of combustion resulting in a higher weight mean and upper bound of the confidence interval.

Table 37. Heat of Combustion Statistics for Region 5.

Year	Wt mean	80% CI
1999	43.04	(42.98, 43.14)
2000	43.09	(42.92, 43.19)
2001	43.12	(43.00, 43.20)
2002	43.21	(43.00, 44.10)
2003	43.11	(42.90, 43.20)
2004	43.13	(42.90, 43.30)
2005	43.16	(43.00, 43.32)
2006	43.08	(43.00, 43.21)
2007	43.12	(43.00, 43.20)
2008	43.11	(43.00, 43.18)

Although the weighted means throughout all years in Region 5 are relatively consistent, the upper bounds of the 95% and 90% confidence intervals were not consistent. The procurement of a larger volume of fuel with a high heat of combustion in the years 2001-2005 causes an increase in the upper bounds of the confidence intervals. Figure 72 shows each individual fuel procurement in Region 5 based on the data from 2001. For each fuel procurement, the heat of combustion and corresponding percent of total volume from Region 5 are shown. The weighted mean heat of combustion is 43.12 MJ/kg and the 95% and 60% confidence intervals are shown. The two large volume fuel procurements in 2001 with a high heat of combustion can clearly be observed.

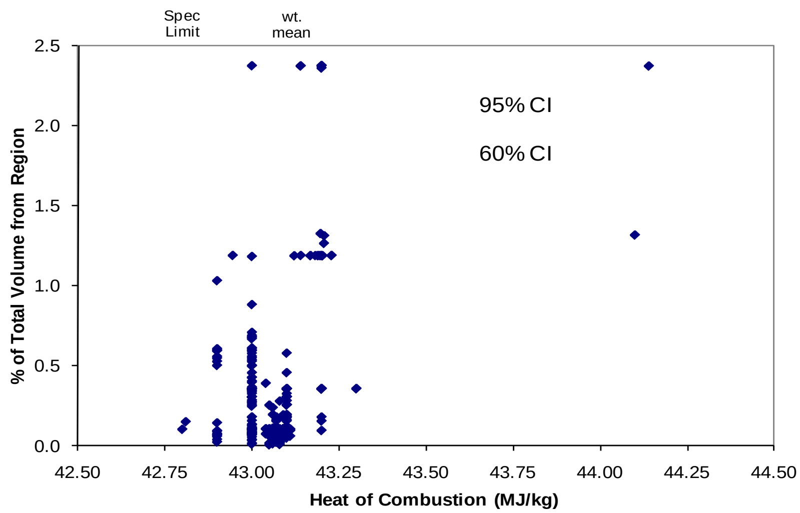

Figure 72. 2001 PQIS Heat of Combustion Data for Region 5.

As shown in Figure 72 by the position of the 95% confidence interval, the data is right-skewed. Due to a few high volume fuel procurements with a high heat of combustion, the right-skewed form of the loglogistic distribution fits the data for Region 5. Figure 73 shows the distribution curves for the years 1999-2008. The distribution curves for all ten years in Region 5 have consistent shapes. The curves are slightly shifted for some years due to small differences in the mean values.

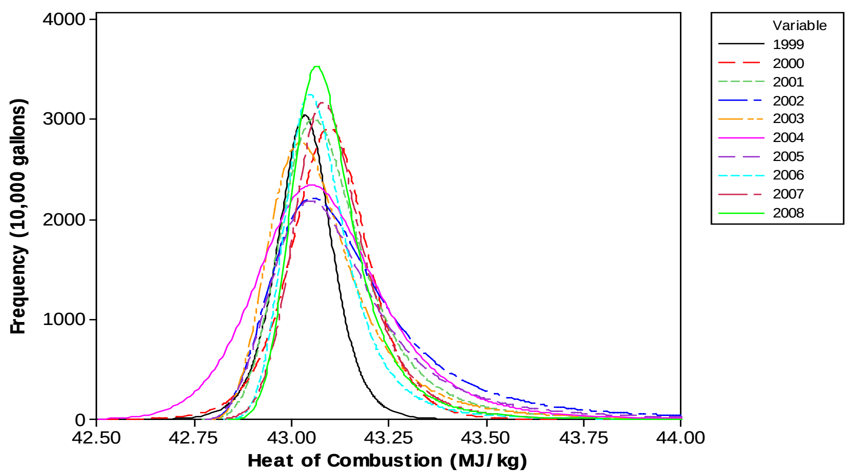

Figure 73. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Heat of Combustion Data for Region 5 from 1999-2008.

The heat of combustion data is consistently right-skewed throughout the years 1999-2008. Some variation exists in the volume of fuel procurements with a high heat of combustion causing inconsistencies in the 95% and 90% confidence intervals. *In general, the heat of combustion of fuel procured in Region 5 has been consistent within a range of 42.90 to 44.00 MJ/kg with a mean value of about 43.10 MJ/kg throughout the years 1999-2008.*

3.1.5.6. CONUS

Table 38 shows the calculated weight mean and 80% confidence interval of the heat of combustion from the 1999-2008 PQIS data for Regions 1-5 of CONUS combined. The weight mean heat of combustion is consistently about 43.20 MJ/kg for all ten years with consistent 80% confidence intervals. Any slight variation in the weight means and 80% confidence intervals are due to differences in the volume of fuels with a low and/or high heat of combustion procured in each year.

Table 38. Heat of Combustion Statistics for CONUS.

Year	Wt mean	80% CI
1999	43.22	(43.00, 43.40)
2000	43.20	(43.01, 43.32)
2001	43.21	(43.00, 43.40)
2002	43.21	(43.01, 43.40)
2003	43.20	(43.00, 43.36)
2004	43.23	(43.00, 43.36)
2005	43.25	(43.08, 43.40)
2006	43.21	(43.05, 43.38)
2007	43.21	(43.00, 43.40)
2008	43.21	(43.00, 43.38)

Although the mean values are consistent, the upper bounds of the 95% confidence intervals in 2002 and 2005 are slightly higher than other years. In these years, there was a few high volume fuel procurement with a heat of combustion higher than in other years. Figure 74 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the heat of combustion and corresponding percent of total volume from CONUS are shown. The weighted mean heat of combustion is 43.21 MJ/kg and the 95% and 60% confidence intervals are shown.

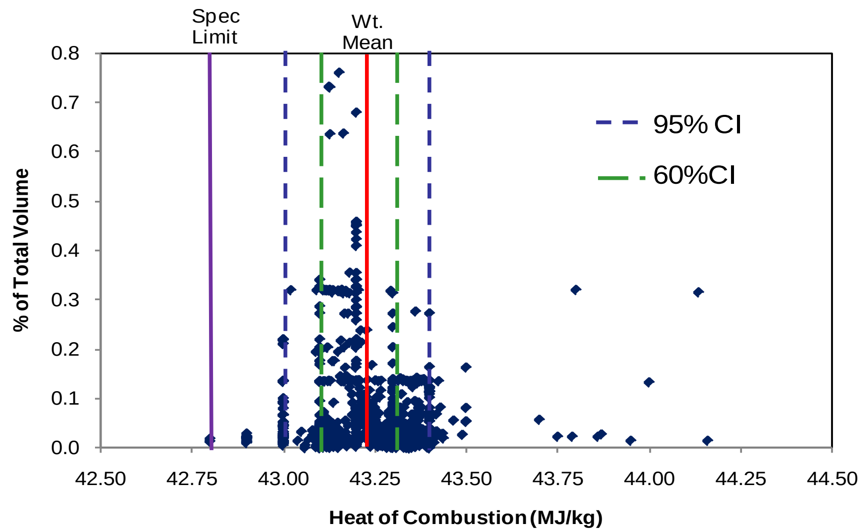

Figure 74. 2008 PQIS Heat of Combustion Data for Regions 2-5.

As shown in Figure 74 by the position of the 95% confidence interval, the data is slightly right-skewed. Due to a few high volume fuel procurements with a high heat of combustion, the right-skewed form of the loglogistic distribution fits the data for CONUS. Figure 75 shows the distribution curves for the years 1999-2008. The distribution curves for all ten years in CONUS have consistent shapes and positions.

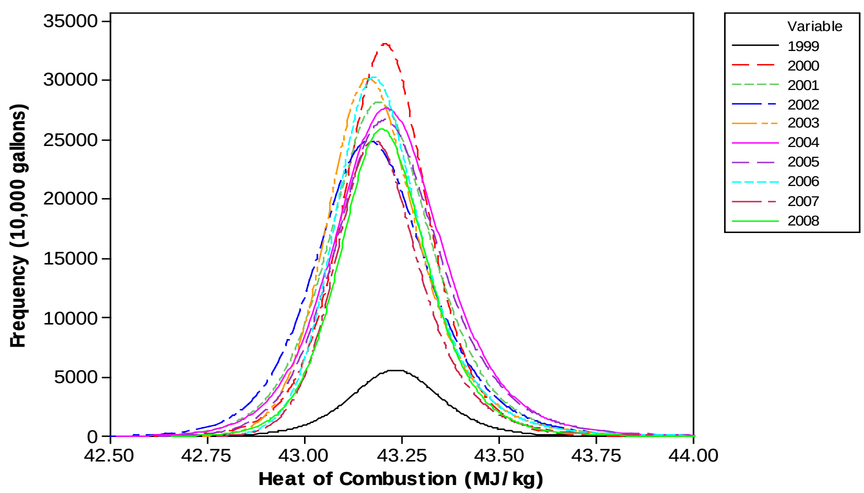

Figure 75. Histogram of the Loglogistic Distribution Fit Curves of the PQIS Heat of Combustion Data for CONUS from 1999-2008.

The heat of combustion data for CONUS combined is consistently right-skewed. The volume of fuel procured in CONUS with a high heat of combustion varied slightly between years resulting in the slight differences in mean values. *In general, the heat of combustion of fuel procured in CONUS has been consistent within a range of 42.90 to 44.00 MJ/kg with a mean value about 43.20 MJ/kg throughout the years 1999-2008.*

3.1.5.7. Variability of Heat of Combustion as a Function of Region

Table 39 shows the calculated weight mean and 80% confidence interval of the heat of combustion from the PQIS data for Regions 1-5 of CONUS from the combined years 1999-2008. The weight mean heat of combustion for Regions 1-5 and CONUS combined are consistently about 43.20 MJ/kg. Regions 2 and 4 have a slightly higher mean heat of combustion of 43.27 MJ/kg due to fewer procurements of fuel with a low heat of combustion than in other regions. Also the mean heat of combustion of Region 5 is lower at 43.13 MJ/kg because of a lower volume of fuel with a high heat of combustion than other years. The 80% confidence intervals are consistent for Regions 1-5 and CONUS combined. The overlap in the confidence intervals is representative of the range of heat of combustion consistent within each region. Figure 76 shows the mean heat of combustion as a function of years from 1999-2008 for Regions 1-5 of CONUS. The fuel procured in Region 2 has a consistently high mean heat of combustion with little variation throughout all years. Overall, the mean heat of combustion of each region is within a range of 43.04 to 43.32 MJ/kg

Table 39. Heat of Combustion Statistics for All Years.

Region	Wt. Mean	80% CI
1	43.21	(43.10, 43.30)
2	43.28	(43.13, 43.35)
3	43.23	(43.10, 43.40)
4	43.27	(43.10, 43.38)
5	43.13	(43.00, 43.23)
CONUS	43.22	(43.00, 43.38)

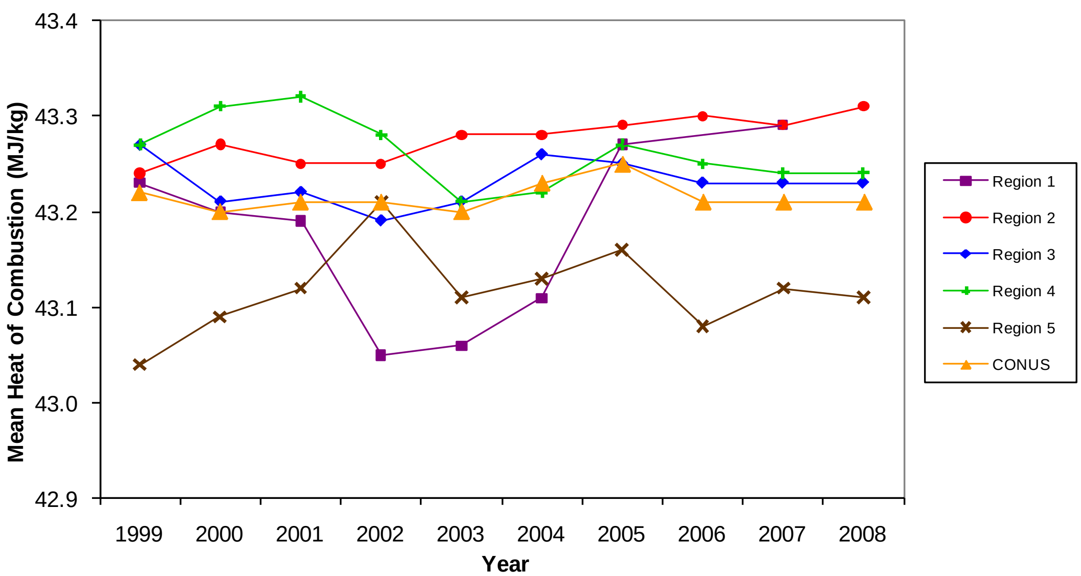

Figure 76. Weight Mean Heat of Combustion for Years 1999-2008 as a Function of Region and CONUS.

Figure 77 shows individual fuel procurements in each region based on the combined data from 1999-2008. For each fuel procurement, the heat of combustion and corresponding percent of total volume from for each procurement are shown. With the exception of a few anomalous procurements of fuel with either a significantly high or low heat of combustion, the range and distribution of the heat of combustion is consistent throughout Regions 1-5 and CONUS combined. *Therefore, the regions may not necessarily need to be considered independently when analyzing property distributions and changes over time. If all regions of CONUS were considered as one, none of the regions would not be largely over or underestimated since they have consistent weight means and confidence intervals.*

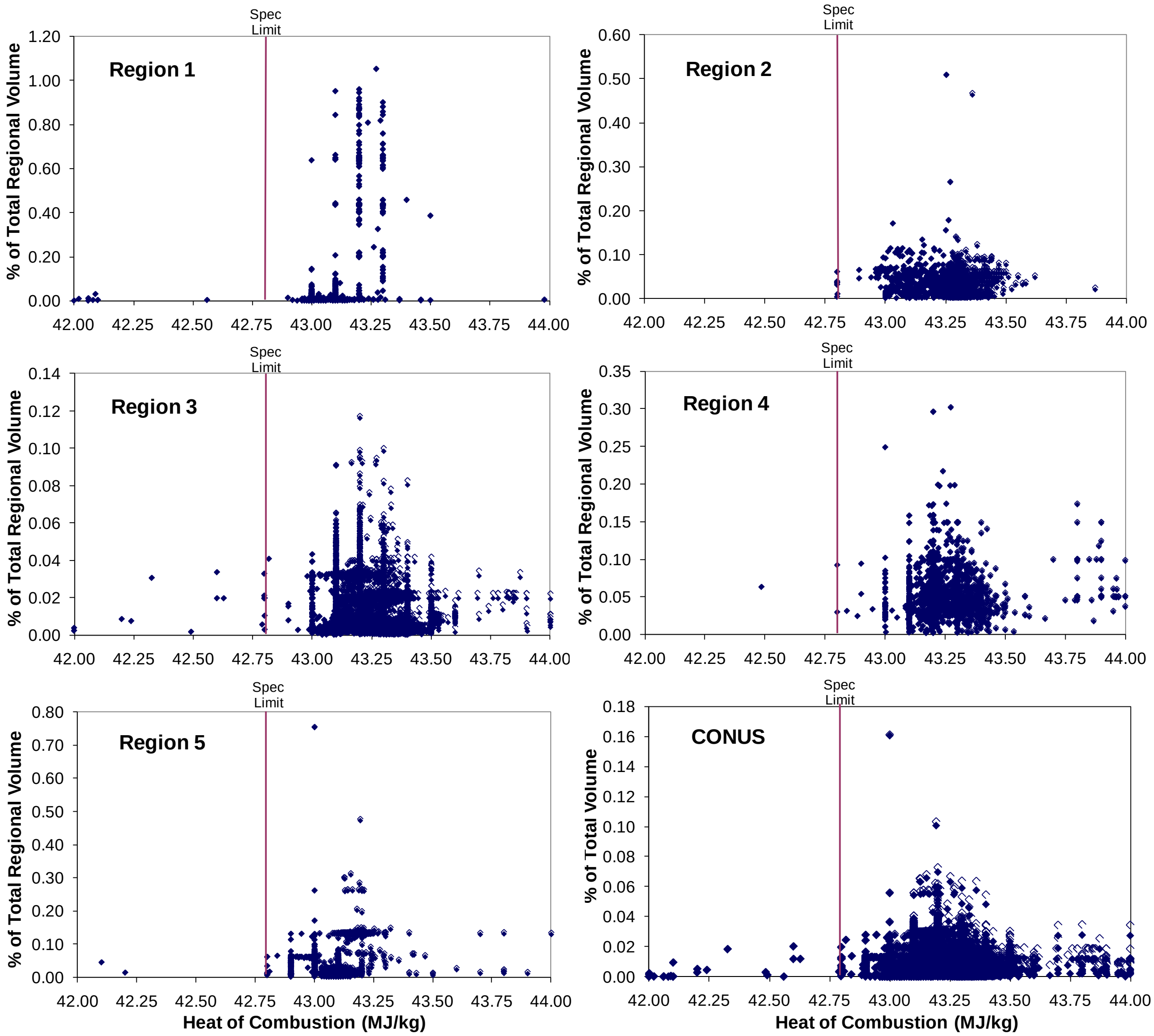

Figure 77. Combined PQIS Heat of Combustion Values from 1999-2008 as a Function of Region.

3.1.5.8. Summary of Heat of Combustion Analysis

In Regions 1-5, there is a trend in the historical heat of combustion data that can be useful in predicting heat of combustion of fuels from these regions. The heat of combustion of fuel procured in Region 1 has been consistent within a range of 43.00 to 43.30 MJ/kg with a mean value of approximately 43.25 MJ/kg. The heat of combustion of fuel procured in Region 2 has been consistent within a range of 43.00 to 43.45 MJ/kg with a mean value of 43.30 MJ/kg. Due to a few fuel procurements with a low heat of combustion in each year, the left-skewed form of the weibull distribution fits the data for Region 1 and 2. The heat of combustion of fuel procured in Region 3 has been consistent within a range of 43.00 to 43.50 MJ/kg with a mean value about 43.20 MJ/kg. The heat of combustion of fuel procured in Region 4 has been consistent within a range of 43.00 to 43.80 MJ/kg with a mean value of about 43.25 MJ/kg. The heat of combustion of fuel procured in Region 5 has been consistent within a range of 42.90 to 44.00 MJ/kg with a mean value of about 43.10 MJ/kg. Due to a few high volume fuel procurements with a high heat of combustion, the right-skewed form of the loglogistic distribution fits the data for Regions 3, 4, and 5.

Analysis of the heat of combustion of each region showed consistent trends within Regions 1-5 and CONUS combined throughout all years 1999-2008. The heat of combustion of fuel procured in CONUS has been consistent within a range of 42.90 to 44.00 MJ/kg with a mean value approximately 43.20 MJ/kg. The data for CONUS is right-skewed because of a number of fuel procurements with a high heat of combustion. A summary of trends in heat of combustion mean statistics and 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 40.

Table 40. Overall Heat of Combustion Statistics for Each Region and CONUS Based on the PQIS Data for 1999-2008.

Region	Mean	60% CI	80% CI
1	43.25	43.10 - 43.30	43.05 – 43.30
2	43.30	43.20 - 43.35	43.15 – 43.40
3	43.20	43.10 - 43.30	43.10 – 43.40
4	43.25	43.15 - 43.30	43.10 – 43.40*
5	43.10	43.00 - 43.20	43.00 – 43.25*
CONUS	43.20	43.10 – 43.30	43.00 – 43.40
*Consistent over last six years, allowing for future prediction.			

Overall, based on the analysis of the heat of combustion of fuel procured in individual Regions 1-5 and CONUS combined, there are minimal differences in the range of the heat of combustion over the years 1999-2008. The prediction of the heat of combustion of fuel based on the analysis of CONUS combined (weight mean of approximately 43.20 MJ/kg) would produce a statistically accurate estimation of the heat of combustion for each region. Therefore, it appears acceptable that the predictability of the heat of combustion by mass of fuel is relatively independent on the CONUS region in which the fuel is procured.

3.1.6. Statistics and Distribution of Volumetric Heating Value

The following section analyzes the calculated volumetric heating value from Regions 1-5 of CONUS for the years 1999-2008. The volumetric heating value was calculated from the PQIS heat of combustion and density data using Equation 6 shown below.

$$VHV(MJ/Liter) = \left(HC\frac{MJ}{kg} \right)\left(Density\frac{g}{mL} \right)\left(\frac{kg}{1000\,g} \right)\left(\frac{1000\,mL}{Liter} \right) \quad \text{(Equation 6)}$$

The complete detailed analysis of the volumetric heating value, the correlation of the distribution with the data, and the confidence intervals based on the data and distribution as a function of region and year is included in Appendix A. The weight mean volumetric heating value and 80% confidence interval are listed for each year in the regions of CONUS within this discussion. The 80% confidence interval is representative of the variation in volume and/or the volumetric heating value of fuel based on the position of the weight mean within the confidence interval and provides guidance regarding general variability in the data. During analysis, the percent of total volume of fuel procured within the region for a given year is also plotted as a function of the volumetric heating value of the fuel. The 95% confidence interval is labeled on the figures to demonstrate the range in the value of the volumetric heating value since a large percentage of the data falls within these intervals. The 60% confidence interval shows the focal or center range in which the value of the volumetric heating value is likely to fall. The data from 2001 for Regions 1-5 and from 2008 for CONUS is plotted in these figures for each region since a large volume of fuel was procured during these years and the relative distribution is representative of fuel procured within a specific region.

3.1.6.1. Region 1

Table 41 shows the calculated weight mean and 80% confidence interval of the volumetric heating value from the 1999-2007 PQIS data for Region 1 of CONUS. No JP-8 fuel was reported as being procured in Region 1 of CONUS in 2006. The weight mean volumetric heating value in 2005 and 2007 was about 34.35 MJ/Liter, but higher in 1999-2001 at about 34.76 MJ/Liter and consistently higher from 2002-2004 at 35.21 MJ/Liter. The weight mean volumetric heating value was lower in 2005 and 2007 due a few of high volume fuel procurements with low volumetric heating value and only a few low volume fuel procurements with high volumetric heating value during that year. In the years 2002-2004, there were a few fuel procurements with a higher volumetric heating value than in other years resulting in a higher mean volumetric heating value. The 80% confidence intervals are inconsistent for most years from 1999-2007. These variations are due to inconsistencies in the range of volumetric heating value and concentration of volume at different levels of volumetric heating between the years.

Table 41. Volumetric Heating Value Statistics for Region 1.

Year	Wt mean	80% CI
1999	34.68	(34.44, 34.89)
2000	34.76	(34.50, 35.02)
2001	34.84	(34.66, 35.18)
2002	35.13	(34.95, 35.29)
2003	35.21	(34.92, 35.39)
2004	35.21	(34.63, 35.61)
2005	34.39	(34.31, 34.39)
2007	34.34	(34.27, 34.42)

Although there is some consistencies in the weight mean volumetric heating value of some years, there is no consistency in the confidence intervals between years. In Region 1, there was few fuel procurements recorded for each year. The few number of fuel procurements reported fall within a large range of volume and volumetric heating values. Figure 78 shows each individual fuel procurement in Region 1 based on the data from 2001. For each fuel procurement, the volumetric heating value and corresponding percent of total volume from Region 1 are shown. The weighted mean volumetric heating value was 34.84 MJ/Liter and the 95% and 60% confidence intervals are shown.

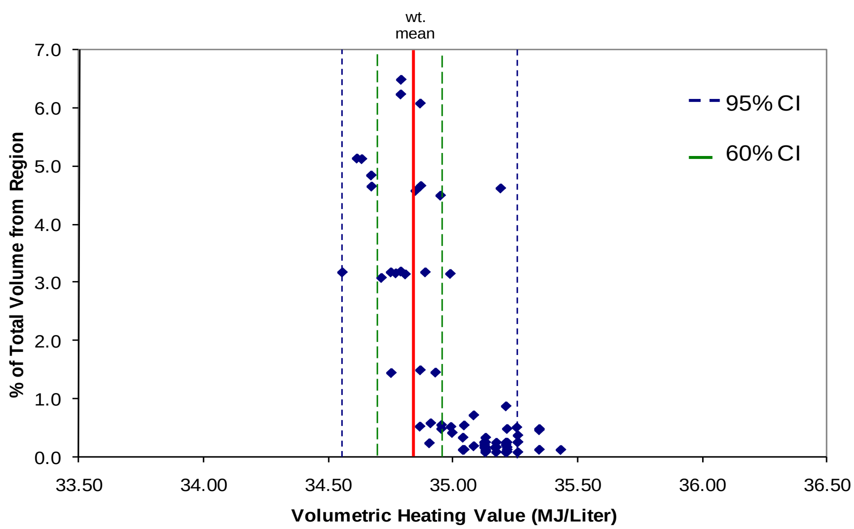

Figure 78. 2001 Volumetric Heating Value Data for Region 1.

As shown in Figure 78 by the position of the 95% confidence interval, the volumetric heating value data is right-skewed. Due to the high volume fuel procurements with low volumetric heating value and a number of low volume procurements with high volumetric heating value within each year, the right-skewed form of the loglogistic probability distribution fits the data for Region 1. Figure 79 shows the loglogistic distribution curves for the years 1999-2007 from Region 1. Since the y-axis is the volume of fuel procured for a specific volumetric heating value, the variation in the height of the curves is due to the differing volumes of fuel procured within each year. The skewness and location of the curves are inconsistent for all years because of the variation in the range of volumetric heating value and volume of fuel procured within each year.

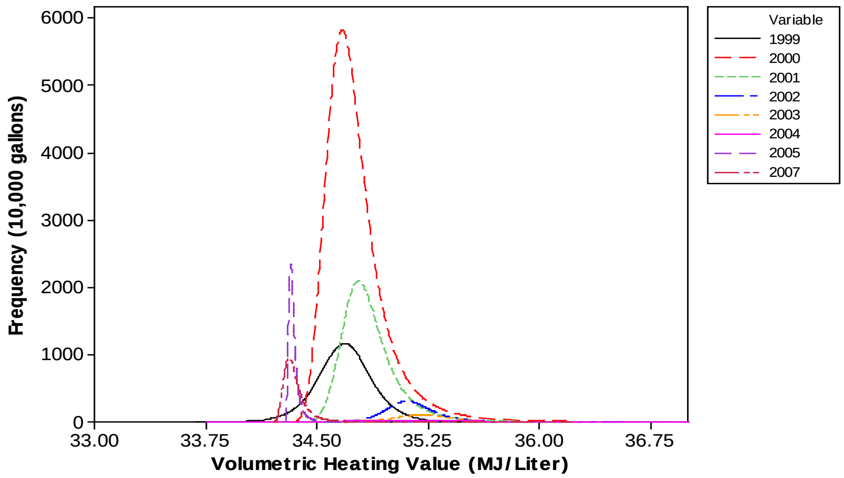

Figure 79. Histogram of the Loglogistic Distribution Fit Curves of the Calculated Volumetric Heating Value Data for Region 1 from 1999-2007.

There is a distinct increase in the volumetric heating value of fuel procured in the years 1999-2001 (34.76 MJ/Liter) to the fuel procured in 2002-2004 (35.21 MJ/Liter). The mean volumetric heating value then decreases in 2005 and 2007 to approximately 34.35 MJ/Liter. The range in the volumetric heating value as well as the volume of each fuel purchase in Region 1 is not consistent for more than three consecutive years from 1999-2007. Therefore, the volumetric heating value of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of trends for CONUS combined.

3.1.6.2. Region 2

Table 42 shows the calculated weight mean and 80% confidence interval of the volumetric heating value from the 1999-2008 PQIS data for Region 2 of CONUS. There is a clear consistency in the weight mean volumetric heating value of about 34.90 MJ/Liter throughout all years. The 80% confidence intervals are fairly consistent for the years. Any slight variations in the weight means and 80% confidence intervals variations in the volume of fuel procured with a high volumetric heating value between years.

Table 42. Volumetric Heating Value Statistics for Region 2.

Year	Wt mean	80% CI
1999	34.92	(34.79, 35.24)
2000	34.87	(34.76, 35.10)
2001	34.89	(34.71, 35.21)
2002	34.92	(34.71, 35.16)
2003	34.92	(34.73, 35.13)
2004	34.97	(34.79, 35.13)
2005	34.89	(34.73, 35.00)
2006	34.89	(34.73, 35.00)
2007	34.81	(34.71, 34.88)
2008	34.84	(34.69, 35.07)

Although the means are consistent for most years in Region 2, the 95% and 90% confidence intervals are not consistent. There is a variation in the upper bound of these confidence intervals due to differing volumes of fuel procured with a high volumetric heating value throughout the years. Figure 80 shows each individual fuel procurement in Region 2 based on the data from 2001. For each fuel procurement, the volumetric heating value and corresponding percent of total volume from Region 2 are shown. The weighted mean volumetric heating value is 34.89 MJ/Liter and the 95% and 60% confidence intervals are shown. As shown in Figure 80, there were a few large volume fuel procurements with a high volumetric heating value resulting in a higher upper bound in the confidence intervals.

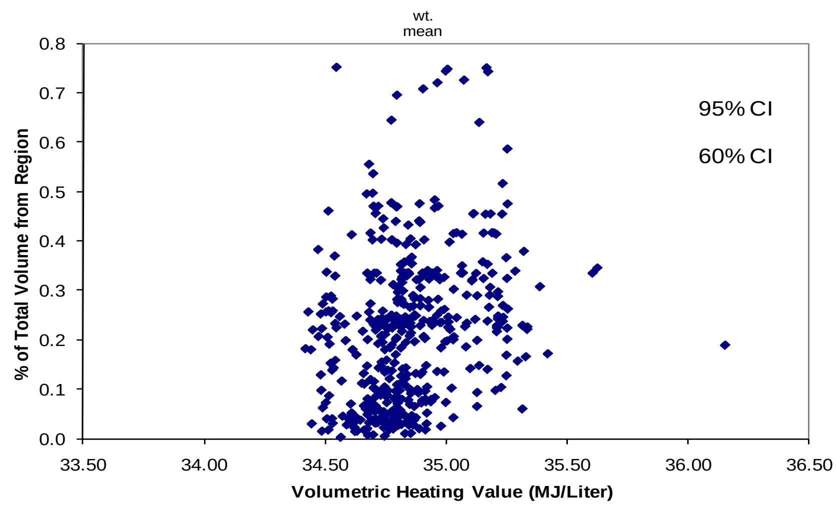

Figure 80. 2001 Volumetric Heating Value Data for Region 2.

As shown in Figure 80 by the confidence intervals, the data is right-skewed. Due to a few procurements of fuel with a high volumetric heating value, the right-skewed form of the loglogistic distribution fits the data for Region 2. Figure 81 shows the loglogistic distribution curves for the years 1999-2008 from Region 2. The distribution curves for all ten years in Region 2 have consistent shapes, but are slightly shifted along the x-axis due to slight variations in the mean values. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

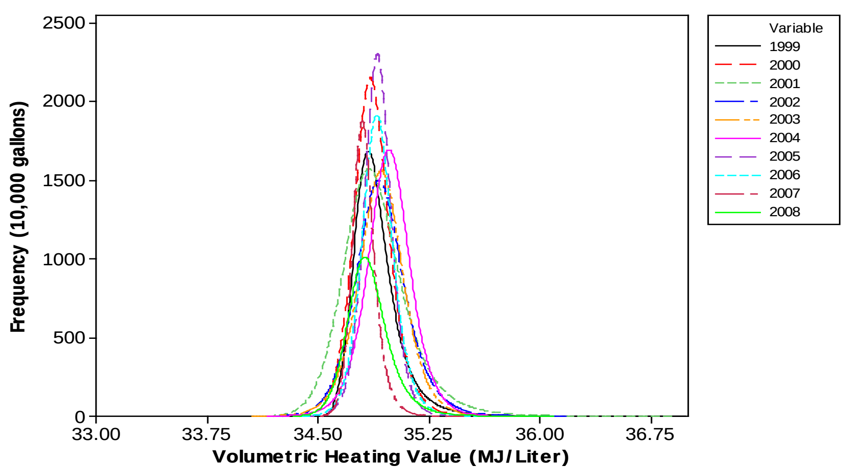

Figure 81. Histogram of the Loglogistic Distribution Fit Curves of the Calculated Volumetric Heating Value Data for Region 2 from 1999-2008.

The volumetric heating value data is consistently right-skewed throughout the years 1999-2008. Some variation exists in the number and volume of fuel procurements with a high volumetric heating value causing slight differences the confidence intervals. *In general, the volumetric heating value of fuel procured in Region 2 has been consistent within a range of - 34.55 to 35.39 MJ/Liter with a mean value of 34.90 MJ/Liter throughout the years 1999-2008.*

3.1.6.3. Region 3

Table 43 shows the calculated weight mean and 80% confidence interval of the volumetric heating value from the 1999-2008 PQIS data for Region 3 of CONUS. With the exception of 2004, all years have a consistent weight mean volumetric heating value of about 34.80 MJ/Liter. The mean volumetric heating value of 2004 is slightly lower at about 34.68 MJ/Liter due to the procurement of a larger volume of fuel with a low volumetric heating value than in the other years. The 80% confidence intervals are all within a consistent range since the volumetric heating value of a bulk of the fuel procured in each year falls within the same range. The lower bound of the 80% confidence interval is slightly lower for some years because more fuel was procured with a low volumetric heating value in these years.

Table 43. Volumetric Heating Value Statistics for Region 3.

Year	Wt Mean	80% CI
1999	34.73	(34.39, 35.13)
2000	34.76	(34.42, 35.16)
2001	34.79	(34.34, 35.10)
2002	34.87	(34.42, 35.18)
2003	34.84	(34.39, 35.13)
2004	34.68	(34.26, 35.10)
2005	34.76	(34.31, 35.10)
2006	34.79	(34.39, 35.10)
2007	34.75	(34.34, 35.02)
2008	34.71	(34.38, 34.95)

In Region 3, the confidence intervals are comparatively consistent for all ten years. Figure 82 shows each individual fuel procurement in Region 3 based on the data from 2001. For each fuel procurement, the volumetric heating value and corresponding percent of total volume from Region 3 are shown. The weighted mean volumetric heating value is 34.79 MJ/Liter and the 95% and 60% confidence intervals are shown. Figure 82 shows the few fuel procurements with a low volumetric heating value that cause the slight variation in lower bound of the confidence intervals between the years

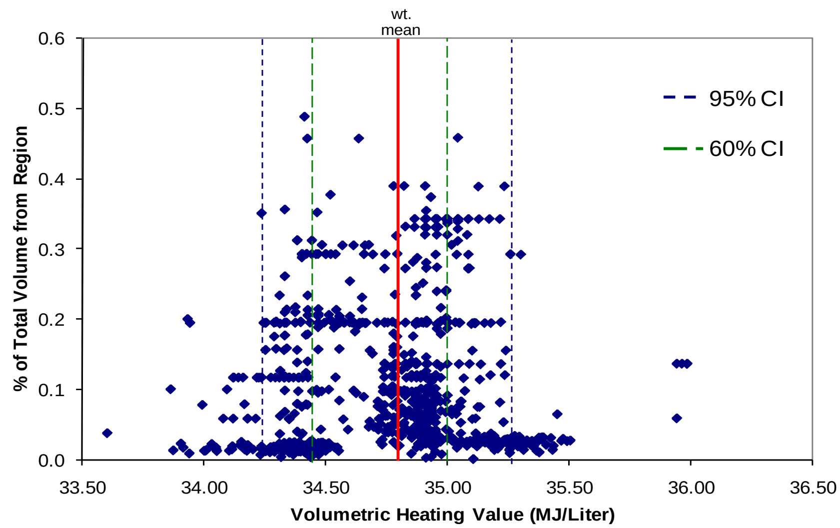

Figure 82. 2001 Volumetric Heating Value Data for Region 3.

As shown in Figure 82, the data slightly is right-skewed. The symmetry of the confidence interval indicates the data maintains a relatively normal shape. Due to a number of fuel procurements with a high volumetric heating value, the right-skewed form of the lognormal distribution fits the data for Region 3. Figure 83 shows the lognormal distribution curves for the years 1999-2008 from Region 3. The distribution curves for all ten years in Region 3 have consistent shapes. The skewness varies because of the differences in the volume of fuel procured with a low volumetric heating value between years. The curves are slightly shifted for some years due to differences in the mean values. The difference in height of the curves is only caused by the differing number of gallons of fuel procured each year.

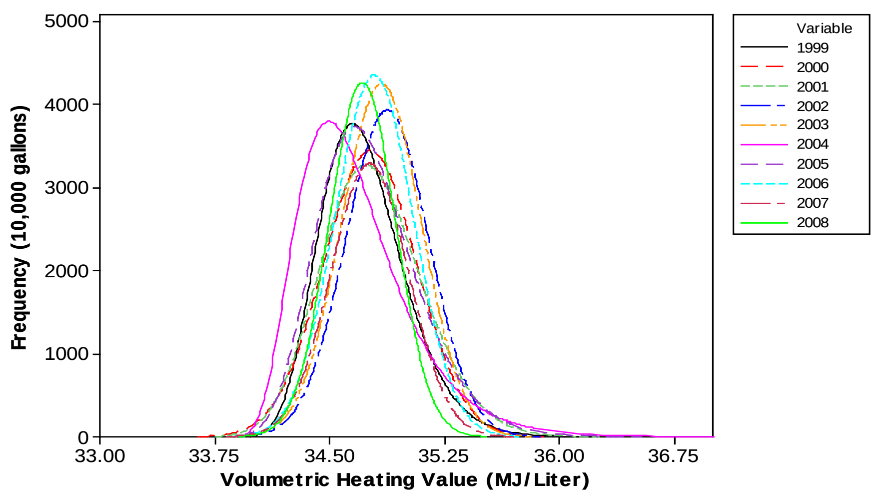

Figure 83. Histogram of the Lognormal Distribution Fit Curves of the Calculated Volumetric Heating Value Data for Region 3 from 1999-2008.

The volumetric heating value data is consistently right-skewed throughout the years 1999-2008. There exists a slight variation throughout the years in the volume of fuel procured in Region 3 with a low volumetric heating value. *In general, the volumetric heating value of fuel procured in Region 3 has been consistent within a range of 34.21 to 35.39MJ/Liter with a mean value about 34.80 MJ/Liter throughout the years 1999-2008.*

3.1.6.4. Region 4

Table 44 shows the calculated weight mean and 80% confidence interval of the volumetric heating value from the 1999-2008 PQIS data for Region 4 of CONUS. With the exception of 2002 and 2007, the weight mean volumetric heating value is consistently about 34.71 MJ/Liter. The years 2002 and 2007 has a slightly higher mean volumetric heating value of 34.89 and 34.86 MJ/Liter due to the procurement of a larger volume of fuel with high volumetric heating value than in other years. In Region 4, there are a low number of fuel procurements. The few fuel procurements in each year of Region 4 have considerable variation in volumetric heating value ranging from 33.73 to 35.95 MJ/Liter. This variation causes the slight difference in weighted means and the upper bounds of the 80% confidence intervals throughout the years, shown in Table 44.

Table 44. Volumetric Heating Value Statistics for Region 4.

Year	Wt mean	80% CI
1999	34.66	(34.44, 34.87)
2000	34.66	(34.50, 34.79)
2001	34.79	(34.52, 35.21)
2002	34.89	(34.50, 35.55)
2003	34.71	(34.50, 34.89)
2004	34.71	(34.52, 34.87)
2005	34.73	(34.44, 35.21)
2006	34.73	(34.42, 35.29)
2007	34.86	(34.40, 35.52)
2008	34.76	(34.48, 35.11)

Due the variation in the density of fuel procured in Region 4, the upper bounds of the confidence intervals are not consistent throughout most of the years in Region 4. Figure 84 shows each individual fuel procurement in Region 4 based on the data from 2001. For each fuel procurement, the volumetric heating value and corresponding percent of total volume from Region 4 are shown. The weighted mean volumetric heating value is 34.79 MJ/Liter and the 95% and 60% confidence intervals are shown. The low number of fuel procurements and variation in volumetric heating value can be seen in Figure 84.

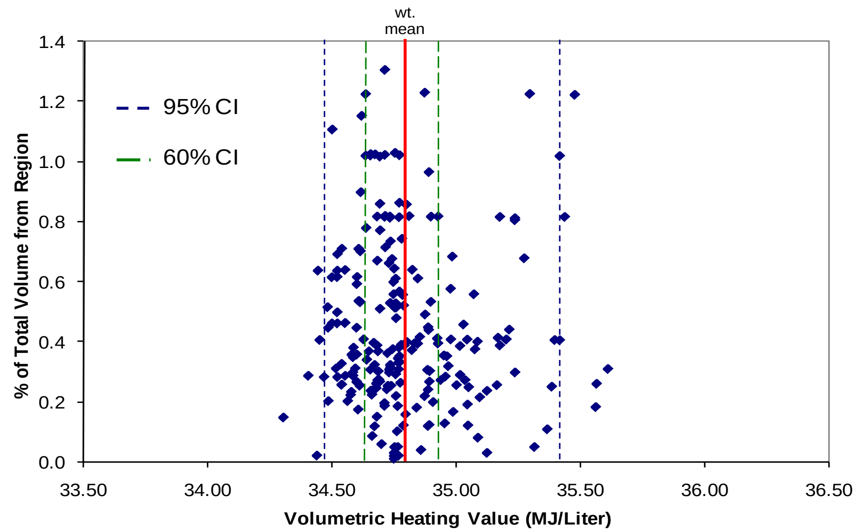

Figure 84. 2001 Volumetric Heating Value Data for Region 4.

As shown by the position of the 95% confidence interval in Figure 84, the data is right-skewed. Due to a few high volume fuel procurements with a high volumetric heating value, the right-skewed form of the loglogistic distribution fits the data for Region 4. Figure 85 shows the loglogistic distribution curves for the years 1999-2008 from Region 4. The distribution curves have a consistent shape and skewness for all years. Slight variations in the position of the curves are caused by the procurement of different volumes of fuel with high volumetric heating value in each year.

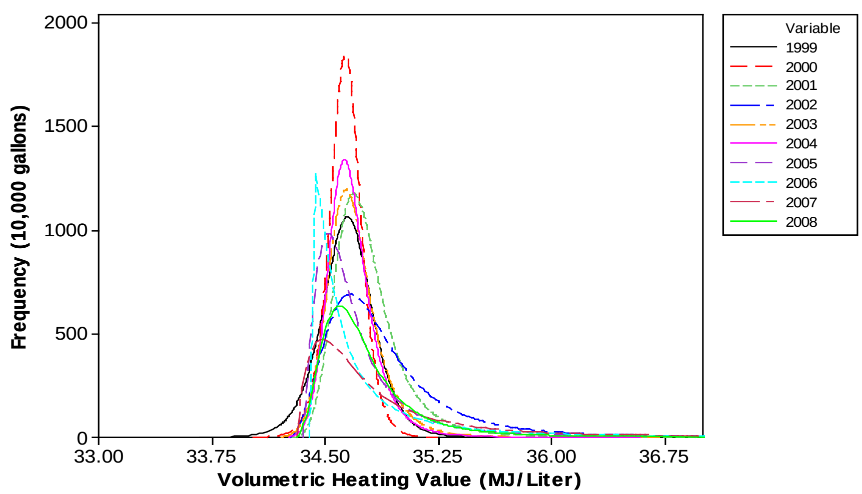

Figure 85. Histogram of the Loglogistic Distribution Fit Curves of the Calculated Volumetric Heating Value Data for Region 4 from 1999-2008.

The volumetric heating value data was consistently right-skewed throughout the years 1999-2008. The procurement and volume of fuel with a high volumetric heating value was not consistent in the years 1999-2008. The range in density as well as the volume of each fuel procurement in Region 4 varies throughout all years. *However, the volumetric heating value of fuel procured in Region 4 has been consistent within a range of 34.29 to 35.39 MJ/Liter with a mean value about 34.71 MJ/Liter throughout the years 1999-2008.*

3.1.6.5. Region 5

Table 45 shows the calculated weight mean and 80% confidence interval of the volumetric heating value from the 1999-2008 PQIS data for Region 5 of CONUS. The weight mean of the volumetric heating value is consistently about 35.39 MJ/Liter throughout all ten years. The 80% confidence intervals are fairly consistent throughout all years. Any slight variations in weight mean and 80% confidence intervals are due to the variation in the volume of fuel procured with a high volumetric heating value within each year. The volumetric heating value is within a consistently large range of 34.55 to 36.24 MJ/Liter for each year.

Table 45. Volumetric Heating Value Statistics for Region 5.

Year	Wt mean	80% CI
1999	35.45	(34.97, 35.95)
2000	35.29	(35.00, 35.95)
2001	35.37	(34.97, 35.95)
2002	35.47	(34.97, 35.90)
2003	35.45	(34.92, 35.95)
2004	35.50	(34.92, 35.92)
2005	35.29	(34.92, 35.76)
2006	35.26	(34.95, 35.66)
2007	35.33	(34.97, 35.91)
2008	35.32	(35.05, 35.78)

As expected from the similar weight means, the confidence intervals are consistent throughout all ten years. Figure 86 shows each individual fuel procurement in Region 5 based on the data from 2001. For each fuel procurement, the volumetric heating value and corresponding percent of total volume from Region 5 are shown. The weighted mean volumetric heating value is 35.37 MJ/Liter and the 95% and 60% confidence intervals are shown. The large range in volumetric heating value can be seen in Figure 44.

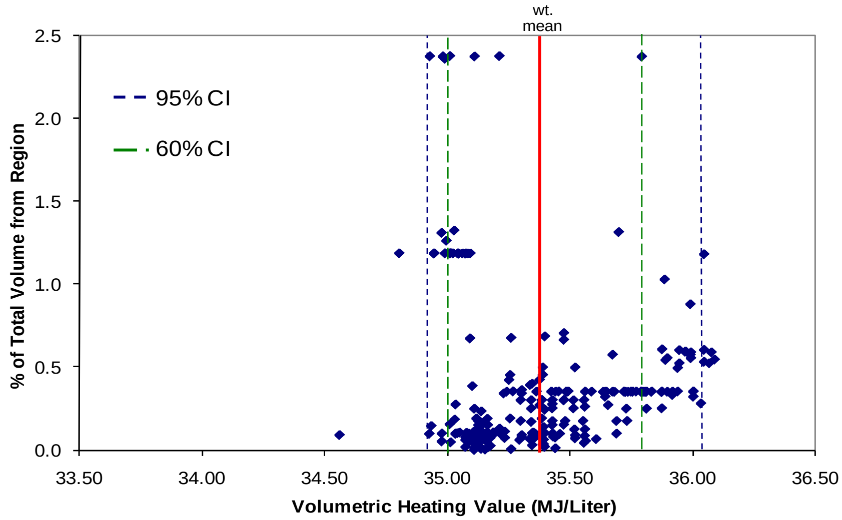

Figure 86. 2001 Volumetric Heating Value Data for Region 5.

As shown in Figure 86, the data is right-skewed. Due to a lower volume of fuel procured with a high volumetric heating value, the right-skewed form of the lognormal distribution fits the data for Region 5. Figure 87 shows the lognormal distribution curves for the years 1999-2008 from Region 5. The skewness of the distribution curves vary due to the different volumes of fuel with a high volumetric heating value procured within each year. The curves are slightly shifted for some years due to small differences in the mean values.

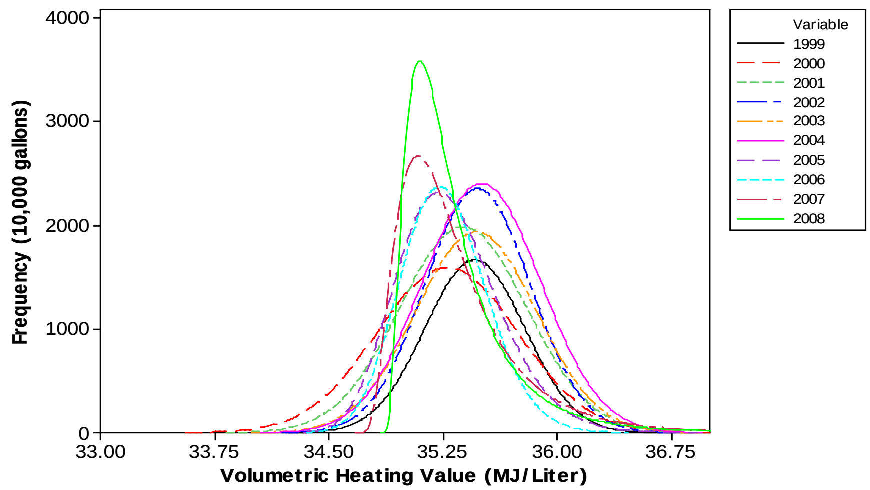

Figure 87. Histogram of the Lognormal Distribution Fit Curves of the Calculated Volumetric Heating Value Data for Region 5 from 1999-2008.

The mean volumetric heating value and the confidence intervals are comparatively consistent throughout the years 1999-2008. Variation exists in the volume of fuel procurements with a high volumetric heating value causing inconsistencies in the skewness of the distribution curves. *In general, the volumetric heating value of fuel procured in Region 5 has been consistent within a range of 34.84 to 35.95 MJ/Liter with a mean value of about 35.39 MJ/Liter throughout the years 1999-2008.*

3.1.6.6. CONUS

Table 46 shows the calculated weight mean and 80% confidence interval of the volumetric heating value from the 1999-2008 PQIS data for Regions 1-5 of CONUS combined. With the exception of 2002 and 2003, the weight mean volumetric heating value is consistently about 34.92 MJ/Liter for all years. In 2002 and 2003, the mean volumetric heating value is slightly higher at 35.00 and 34.97 MJ/Liter due to a larger volume of fuel procured with a high volumetric heating value in these years. The 80% confidence intervals are relatively consistent for all years. The lower bounds of the 80% confidence interval are lower in 2004 and 2005 because of the procurement of a larger volume of fuel with a low volumetric heating value in these years. The upper bounds of the 80% confidence interval are higher in the years 2002-2004 due to a number of low volume fuel procurements with a very high volumetric heating value.

Table 46. Volumetric Heating Value Statistics for CONUS.

Year	Wt Mean	80% CI
1999	34.87	(34.44, 35.45)
2000	34.87	(34.47, 35.26)
2001	34.92	(34.42, 35.42)
2002	35.00	(34.55, 35.66)
2003	34.97	(34.52, 35.61)
2004	34.89	(34.29, 35.74)
2005	34.87	(34.37, 35.39)
2006	34.89	(34.44, 35.24)
2007	34.91	(34.42, 35.54)
2008	34.87	(34.44, 35.25)

Since the weighted means are consistent throughout all years in CONUS, the confidence intervals are also fairly consistent. Figure 88 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the volumetric heating value and corresponding percent of total volume from CONUS are shown. The weighted mean freeze volumetric heating value is 34.89 MJ/Liter and the 95% and 60% confidence intervals are shown.

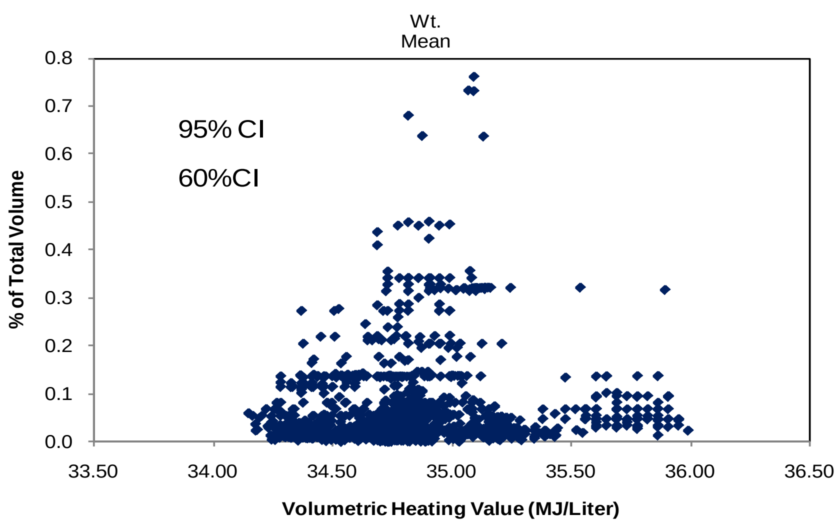

Figure 88. 2008 Volumetric Heating Value Data for Regions 2-5.

As shown in Figure 88 by the position of the 95% confidence interval, the data is right-skewed. Due to a few high volume fuel procurement with a high volumetric heating value, the right-skewed form of the loglogistic distribution fits the data for CONUS. Figure 89 shows the loglogistic distribution curves for the years 1999-2008 from CONUS. The distribution curves for all ten years in CONUS have consistent shapes and positions due to consistent weight mean values.

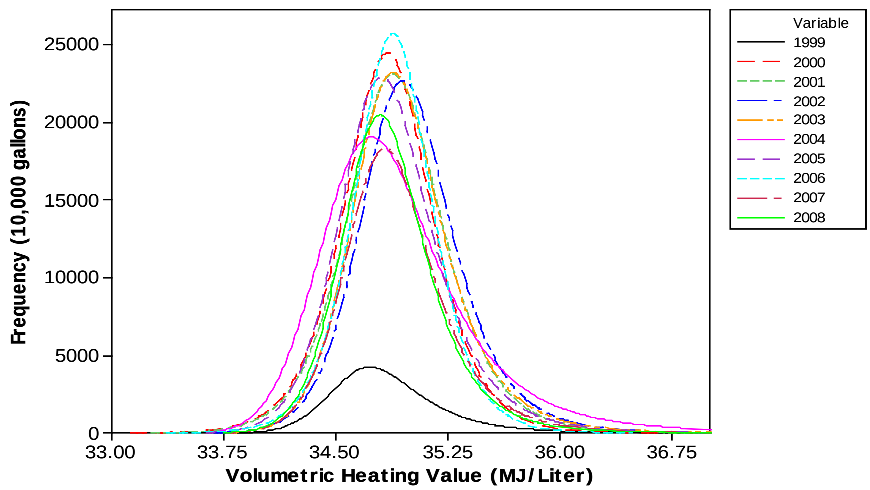

Figure 89. Histogram of the Loglogistic Distribution Fit Curves of the Calculated Volumetric Heating Value Data for CONUS from 1999-2008.

The volumetric heating value data for CONUS combined is consistently right-skewed. The volume of fuel procured in CONUS with a high volumetric heating value varied slightly between years resulting in the slight differences in mean values. *In general, the volumetric heating value of fuel procured in CONUS has been consistent within a range of 34.29 to 35.95 MJ/Liter with a mean value about 34.92 MJ/Liter throughout the years 1999-2008.*

3.1.6.7. Variability of Volumetric Heating Value as a Function of Region

Table 47 shows the calculated weight mean and 80% confidence interval of the volumetric heating value from the PQIS data for Regions 1-5 of CONUS from the combined years 1999-2008. With the exception of Region 5, the mean volumetric heating value is about 34.80 MJ/Liter. In Region 5, there was a smaller volume of fuel procured than in other regions with a volumetric heating value of less than 34.84 MJ/Liter resulting in the higher mean value of 35.38 MJ/Liter. Unlike Regions 1, 3-5 and CONUS combined, no fuel was recorded in Region 2 with a volumetric heating value below 34.00 MJ/Liter resulting in the lower bound for the 80% confidence interval to be higher in Region 2 than all other regions. The upper bounds of the 80% confidence intervals are consistent with the exception of Region 5 and CONUS combined. The upper bound is higher in these regions due to a large volume of fuel procured in Region 5 with a volumetric heating value near 36.24 MJ/Liter. The overlap in the confidence intervals is representative of the range of volumetric heating value consistent within each region. However, the mean volumetric heating value and 80% confidence interval of CONUS combined is significantly less than the statistics for Region 5. Thus the range and distribution in the volumetric heating value of fuel procured within each region may need to be considered separately. Figure 90 shows the mean volumetric heating value as a function of years from 1999-2008 for Regions 1-5 of CONUS. The fuel procured in Region 5 has a consistently higher mean volumetric heating value than all other regions.

Table 47. Volumetric Heating Value Statistics for All Years.

Region	Wt. Mean	80% CI
1	34.75	(34.37, 35.35)
2	34.90	(34.57, 35.03)
3	34.76	(34.34, 35.09)
4	34.72	(34.47, 35.17)
5	35.38	(34.97, 35.90)
CONUS	34.90	(34.42, 35.44)

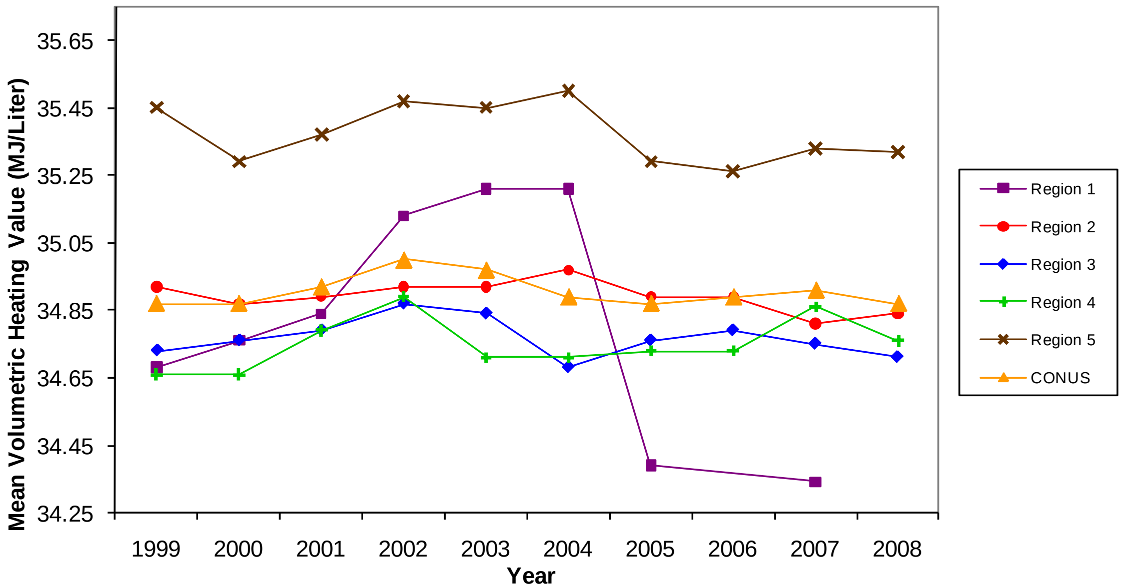

Figure 90. Weight Mean Volumetric Heating Value from Years 1999-2008 as a Function of Region and CONUS.

Figure 91 shows each individual fuel procurement in each region based on the combined data from 1999-2008. For each fuel procurement, the volumetric heating value and corresponding percent of total volume from each region are shown. As shown in Figure 91, each region shares a similar distribution of volumetric heating value data. However the range in volumetric heating value for Region 5 is significantly higher than Regions 1-4. If all regions of CONUS were considered as one, the volumetric heating value of a portion of the fuel procured in Regions 5 will be largely underestimated. Therefore, the regions may need to be considered independently when analyzing property distributions and changes over time.

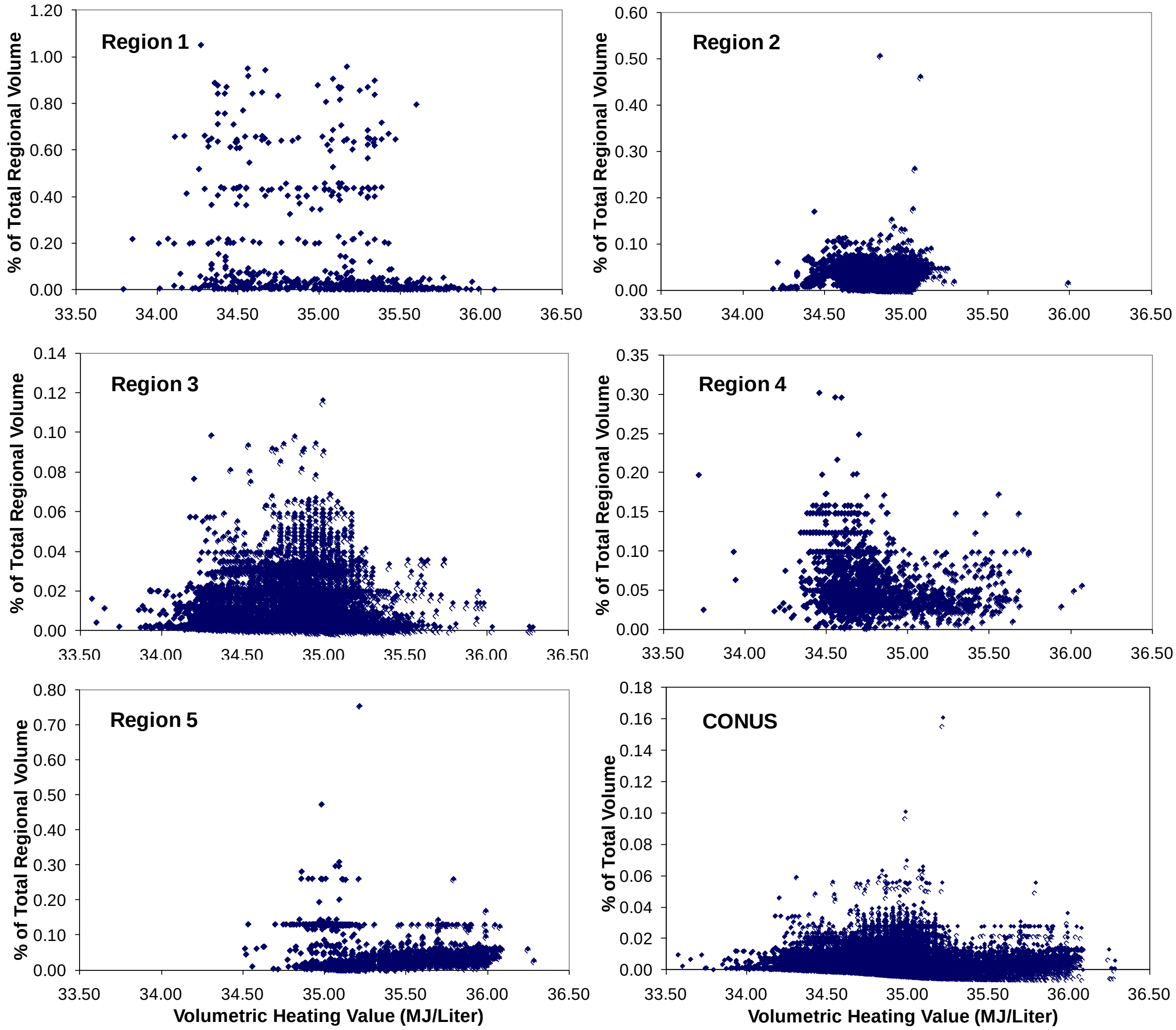

Figure 91. Combined PQIS Volumetric Heating Value from 1999-2008 as a Function of Region.

3.1.6.8. Summary of Volumetric Heating Value Analysis

Based on the historical volumetric heating value data from Region 1, there is no consistency in the volumetric heating value of fuel procured throughout all years. There is a distinct increase in the volumetric heating value of fuel procured in the years 1999-2001 (34.76 MJ/Liter) to the fuel procured in 2002-2004 (35.21 MJ/Liter). The mean volumetric heating value then decreases in 2005 and 2007 to approximately 34.35 MJ/Liter. The range in the volumetric heating value as well as the volume of each fuel purchase in Region 1 is not consistent for more than three consecutive years from 1999-2007. Therefore, the volumetric heating value of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of historical trends.

In Regions 2-5, there is a trend in the historical volumetric heating value data that can be useful in predicting the volumetric heating value of fuels from these regions. The volumetric heating value of fuel procured in Region 2 has been consistent within a range of 34.55 to 35.39 MJ/Liter with a mean value of 34.90 MJ/Liter. The volumetric heating value of fuel procured in Region 4 has been consistent within a range of 34.29 to 35.39 MJ/Liter with a mean value about 34.71 MJ/Liter. Due to a few high volume fuel procurements with a high volumetric heating value, the right-skewed form of the loglogistic distribution fits the data for Regions 2 and 4. The volumetric heating value of fuel procured in Region 3 has been consistent within a range of 34.21 to 35.39 MJ/Liter with a mean value about 34.80 MJ/Liter. The volumetric heating value of fuel procured in Region 5 has been consistent within a range of 34.84 to 35.95 MJ/Liter with a mean value of about 35.39 MJ/Liter. Due to a number of fuel procurements with a high volumetric heating value, the right-skewed form of the lognormal distribution fits the data for Regions 3 and 5.

From the analysis of the volumetric heating value of each region it is apparent that there exists consistent trends within Regions 2-5 and CONUS combined. The volumetric heating value of fuel procured in Region 1 is inconsistent throughout all years 1999-2008. The volumetric heating value of fuel procured in CONUS has been consistent within a range of 34.29 to 35.95 MJ/Liter with a mean value about 34.92 MJ/Liter. The data for CONUS is right-skewed because of a few high volume fuel procurements with a high volumetric heating value. Although the combined analysis of CONUS was consistent, the difference in the volumetric heating value in Region 5 and Regions 1-4 is too significant to ignore and analyze all regions together. It is noteworthy that although the heat of combustion by mass for Region 5 showed the lowest mean values, the calculated VHV is higher due to the significantly higher mean density values. A summary of trends in volumetric heating value mean statistics and 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 48. With the exception of Region 1, the volumetric heating value of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 48.

Table 48. Overall Volumetric Heating Value Statistics for Each Region and CONUS Based on the PQIS Data for 1999-2008.

Region	Mean	60 % CI	80% CI
1	**	**	**
2	34.90	34.80 - 35.02	34.75 – 35.10
3	34.80	34.50 - 35.00	34.40 – 35.10
4	34.71	34.55 – 34.95	34.45 – 35.30*
5	35.39	35.05 - 35.75	34.97 – 35.90
CONUS	34.92	34.60 - 35.10	34.45 – 35.40

*Consistent over last four years, allowing for future prediction.
** Not consistent for consecutive years, cannot be predicted.

Overall, based on the analysis of the volumetric heating value of fuel procured in individual Regions 1-5 and CONUS combined, there is a statistical difference in the range of the volumetric heating value of fuel procured in Region 5 from the fuel procured in Regions 1-4. The prediction of the volumetric heating value of fuel based on the analysis of

CONUS combined would not necessarily produce a statistically accurate estimation of the volumetric heating value of Region 5. Therefore, the predictability of the volumetric heating value of fuel is dependent on the region of CONUS in which the fuel is procured.

3.1.7. Correlations Between Properties

Analysis was performed to determine if correlations exist between any of the JP-8 fuel properties discussed in the preceding sections. Specifically, parity plots of the PQIS data were made for comparison. The existence of a correlation between any two JP-8 properties could further assist to predict the expected value of a property with knowledge of the other. The PQIS data from the year 2003 contained the largest number of fuel procurements and is thus used to illustrate the presence or lack of correlations between selected JP-8 fuel properties. Data from 1999-2008 consistently show similar correlations between properties as those from 2003; the correlations for 2008 are included in Appendix A.

3.1.7.1. Properties with Positive Correlations

In general, a positive correlation between fuel properties exists when there is a concurrent increase in both property values. As shown in Figure 97.a-c, there is a positive correlation between the Viscosity and Density, Volumetric Heating Value and Density, and Volumetric Heating Value and Viscosity of JP-8 fuel. The kinematic viscosity and density are most likely related by the corresponding chemical constituents in the fuel and normalization of the dynamic viscosity by density. The volumetric heating value and the density are related by the nature of density being used to calculate the VHV from the heat of combustion by mass. The VHV and viscosity are most likely related due to both having a positive correlation with density.

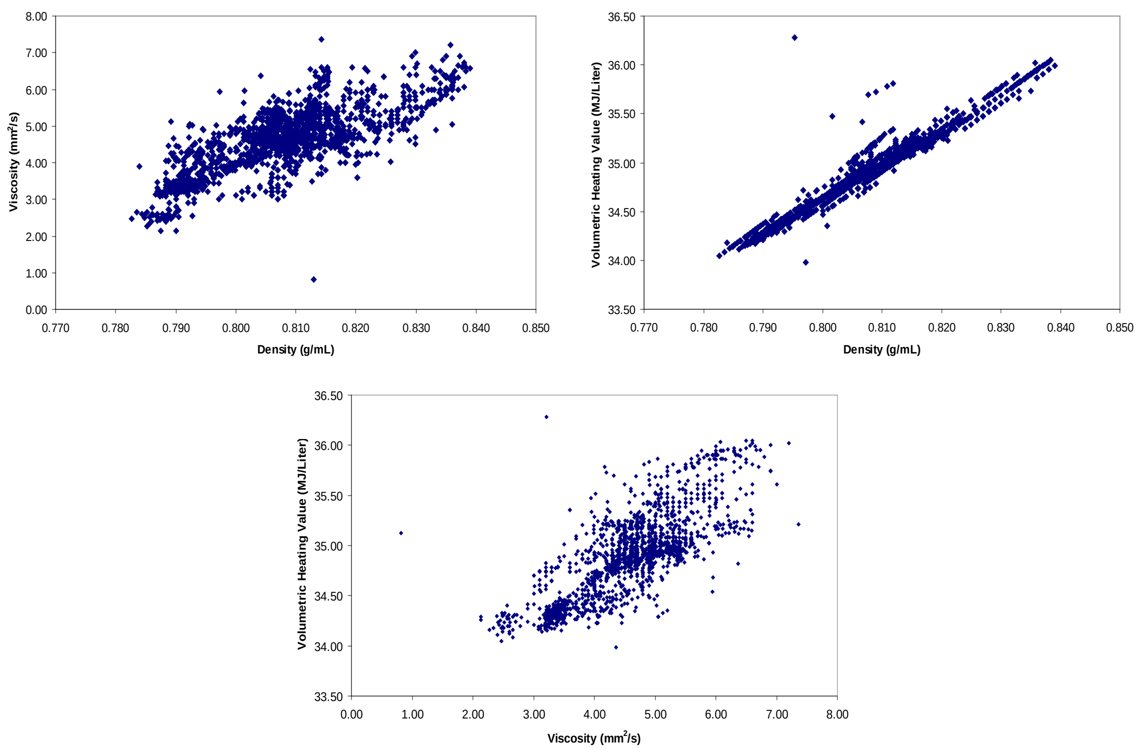

Figure 92.a-c. Plot of JP-8 Property Comparisons with Positive Correlations.

3.1.7.2. Properties with Negative Correlations

A negative correlation between fuel properties exists when an increase in one variable coincides with a decrease in another property. As shown in Figure 93.a-d, there exists a negative correlation between the Density and Heat of Combustion, Aromatic Content and Heat of Combustion, Viscosity and Heat of Combustion, and the Volumetric Heating Value and Heat of Combustion of JP-8 fuel. The correlation between density and heat of combustion are most likely related to the hydrogen content of the fuel (paraffinic compounds have higher hydrogen content with lower density). Likewise, the aromatic content correlation could be attributed to the same cause; however, there appears to be more scatter in the correlation. The viscosity and VHV correlations could be related to bulk chemical composition of the fuels and since the heat of combustion by mass and VHV are related linearly via density.

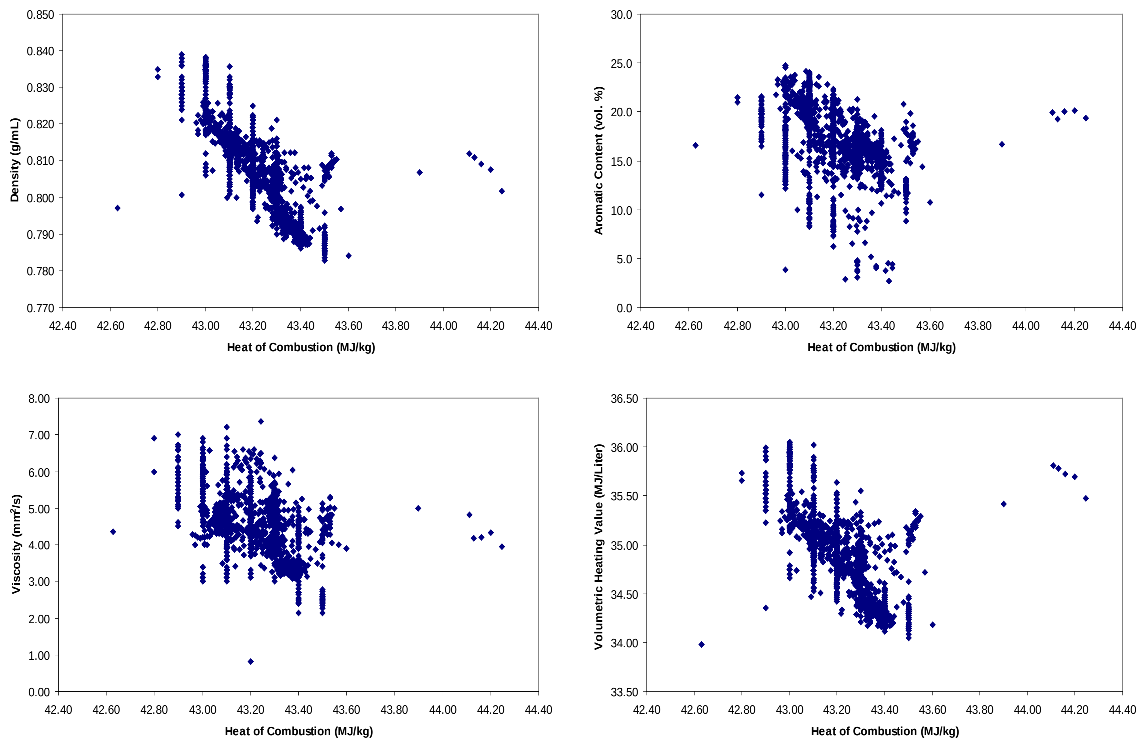

Figure 93.a-d. Plot of JP-8 Property Comparisons with Negative Correlations.

3.1.7.3. Properties with Weak Correlations

During comparison of the selected fuel properties, there is no recurring correlation pattern between the values of the JP-8 fuel properties for some cases. As Figure 94.a-f shows, there is no distinct correlation between the Freeze Point and any other property considered or for the Aromatic Content with Density, Viscosity or Volumetric Heating Value. The lack of correlations for the freeze point is reasonable since this property is primarily influenced by the long chain *n*-alkane concentration in the fuel. These components are not typically indicative of any bulk property in a fuel but rather related to the distillation range and end point during production. In addition, as discussed in the preceding sections, the fuel is only produced to satisfy the maximum freeze point (-47°C) and not typically processed further. The lack of a strong correlation between aromatic content and the density was surprising, as it is typically believed that an increase in density is primarily due to the incorporation of denser aromatic compounds in exchange for less dense normal and *iso*-paraffins. However, it can be observed that there must be additional chemical properties which affect these two properties in a non-linear manner. One potential explanation is the incorporation of cycloparaffins for the linear constituents or a shift to higher molecular weight compounds; this could render increases in the bulk density of the fuel without a concurrent increase in the aromatic content. This behavior most likely merits further study.

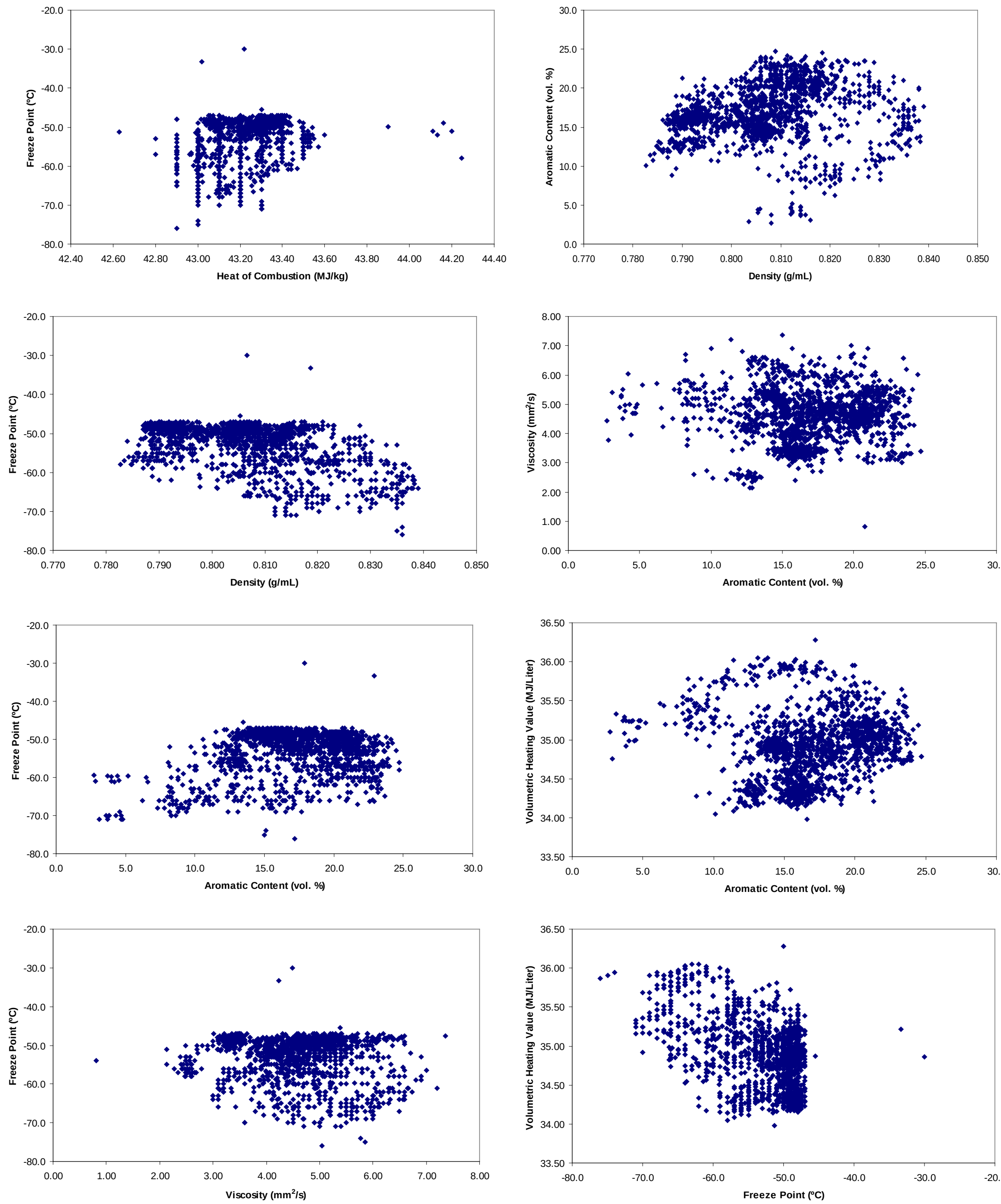

Figure 94.a-h. Plot of JP-8 Property Comparisons with Weak Correlations.

3.2. Implications of Blending JP-8 with SPK

The recently modified JP-8 (MIL-DTL-83133F) and commercial Jet A and Jet A-1 (ASTM D7566) specifications allow for blending of up to 50% by volume (vol. %) of Synthetic Paraffinic Kerosene (SPK). The specifications currently require that the SPK must be produced via the Fischer-Tropsch (FT) process, is free of aromatics (< 1.0 volume % for JP-8 and < 0.5% for Jet A/A-1), and has a minimum density of 0.751 g/mL (JP-8) or 0.730 g/mL (Jet A/A-1). However, the 50/50 vol. % fuel blend must have a minimum aromatic content of 8.0 volume % and density of 0.775 g/mL for use in either military or commercial applications. Due to the nature of the SPK (lower density and aromatic-free), the addition of SPK to JP-8 will decrease the density and aromatic content of the blend relative to the neat fuel. Depending on the properties of the petroleum-derived fuels, the addition of SPK can decrease the density and aromatic content below the blend specification limits. Knowledge of the property dependence with blend ratio would allow for prediction of resulting properties. For an SPK which has a high *iso*-/normal paraffin ration and a similar distillation range to a typical JP-8 fuel, a linear dependence of the primary specification properties with blend ratio has been found to exist. The aromatic content and density have been found to vary linearly with blend concentration provided that the SPK has a volatility range similar to a typical JP-8.[8] The maximum allowable percentage of synthetic fuel while still satisfying the fuel specifications (either military of commercial) can be calculated using Equations 7 and 8.

$$\left[1 - \left(\frac{8.0 - Aromatic\ Content\ of\ FT\ fuel}{Aromatic\ Content\ of\ JP-8 \quad - \quad Aromatic\ Content\ of\ FT\ fuel}\right)\right] \times 100 \qquad \text{(Equation 7)}$$

$$\left[1 - \left(\frac{0.775 - Density\ of\ FT\ fuel}{Density\ of\ JP-8 \quad - \quad Density\ of\ FT\ fuel}\right)\right] \times 100 \qquad \text{(Equation 8)}$$

In order to ensure the aromatic content and density of the blend does not decrease below the JP-8 specification limit of 8.0 vol. % and 0.775 g/mL, the percentage of SPK at which the aromatic content and density of the blend reaches the limit must be calculated. Using Equation 7 with an aromatic content of 0 vol. % for the SPK and Equation 8 with a density of 0.751 g/mL for the synthetic fuel, the maximum allowable percentage of SPK in a blend with JP-8 while still satisfying the specification requirement can be calculated for each CONUS region and year using PQIS data. In the event that an SPK has a higher aromatic or density value, the minimum allowable blend ratio would increase. A similar analysis could be performed for commercial application with available data. The values used for the aromatic content and density of JP-8 in the calculations are the lower bounds of the 95%, 90% and 80% confidence intervals and distributions from the PQIS data. Within each region, the maximum percent of SPK in the blend is consistent throughout the years 1999-2008 with the exception of years where there was a procurement of fuel with aromatic content and/or density below the normal specifications for JP-8. The calculation of the maximum percentage of synthetic fuel in the blend for the 95%, 90% and 80% confidence intervals based on the PQIS data and distribution of PQIS data from all years can be found in Appendix A.

Discrete analysis of the historical JP-8 procurement data was performed in the next two sections to calculate the percentage of 50/50 vol. % fuel blends which would not satisfy the JP-8/SPK blend specification requirements of 8.0 vol. % aromatic content and 0.775 g/mL density. JP-8 procurements were analyzed independently as a function of both year and region in which the fuel was procured. The data from the individual regions are then combined for all CONUS to determine if statistical differences exist and if regions should be considered individually when implementing the use of JP-8/SPK blends.

3.2.1 Aromatic Content of JP-8/SPK Blends

The following sections discuss analyses which were performed to calculate the percent of the total fuel volume procured, when blended with 50 vol. % of SPK, that would not satisfy the minimum blend specification for aromatic content of 8.0 vol. %. The analyses were performed for Regions 1-5 of CONUS using the PQIS data from 1997-2008 to attempt to identify anticipated future trends. It was assumed that the SPK did not contain aromatic components, which is the most conservative case. Therefore, a JP-8 fuel must have a minimum aromatic content of 16.0 vol. % to satisfy the 8.0 vol. % minimum blend content. It should be noted that this analysis was performed using the discrete PQIS data; functional fits were not employed. Thus, the reported values and trends are based completely on the actual fuel properties/volumes procured from 1997-2008. The mean aromatic values shown in Figure 20 were useful in understanding general trends, but do not represent the breadth of the data (see Figure 21 and Table 8). If only the mean values are only considered, it is possible to erroneously assume that the majority of fuel blends will satisfy the specification since the mean values were all greater than 16.0% except for Region 2. In the following sections, the percent of total volume of fuel within the region for a specific year is plotted as a function of the PQIS aromatic content of the fuel in addition to the calculated aromatic content of a 50 vol. % SPK blend. The minimum specification limit for a blend of JP-8 and SPK (8.0 vol. %) is labeled on the figures to demonstrate the frequency of fuel procurements that would not satisfy the minimum limit. The data from 2008 is plotted in these figures for Regions 2-5 and CONUS combined to demonstrate the most recent trends. The data from 2004 is plotted for Region 1 due to the small amount of fuel procured in 2005 and 2007-2008 and the lack of fuel procured in 2006 in Region 1.

3.2.1.1 Predicted Aromatics of Blend Based on the PQIS Data for Region 1

Table 49 shows the percentage of fuel with an aromatic content below the minimum specification (8.0 vol. %) when blended with 50 vol. % of SPK from the 1997-2005 and 2007-2008 PQIS Data for Region 1 of CONUS. The differing percentages, shown in Table 49, are expected from the inconsistencies between years discussed in section 3.1.1.1. The number of fuel procurements and volume of fuel with an aromatic content below 16.0 vol. % was not consistent throughout all years in Region 1. As expected from the shift in mean aromatic content from the years 1997-2001 to 2002-2008 (section 3.1.1.1), the percent of fuel with aromatic content below 16.0 vol. % is statistically higher in the years 1997-2001 than in 2002-2005 and 2007. The procurement of one large volume batch of fuel in 2008 with aromatic content below 16.0 vol. % accounts for the slightly higher percentage in that year than in 2002-2005 and 2007.

Table 49. Percent of Fuel with Aromatic Content Below 8.0 vol. % when Blended with 50 vol. % of SPK Based on PQIS Data from Region 1.

Year	Percent Below 8.0 vol. %
1997	40.5
1998	38.2
1999	19.6
2000	27.4
2001	55.0
2002	—
2003	0.8
2004	9.7
2005	0.2
2007	—
2008	12.0

Figure 95 shows each individual fuel procurement in Region 1 based on the data from 2004. For each fuel procurement, the aromatic content of the JP-8 fuel as well as the calculated 50 vol. % blend value and corresponding percent of total volume from Region 1 are shown. As shown, 9.7 % of the fuel procured in 2004 from Region 1 has an aromatic content that falls below the minimum blend specification when blended with 50 percent volume of SPK. The distribution of the 50/50 blend, compared to the distribution of JP-8 fuel, is shifted along the x-axis and extends over a narrower range of values.

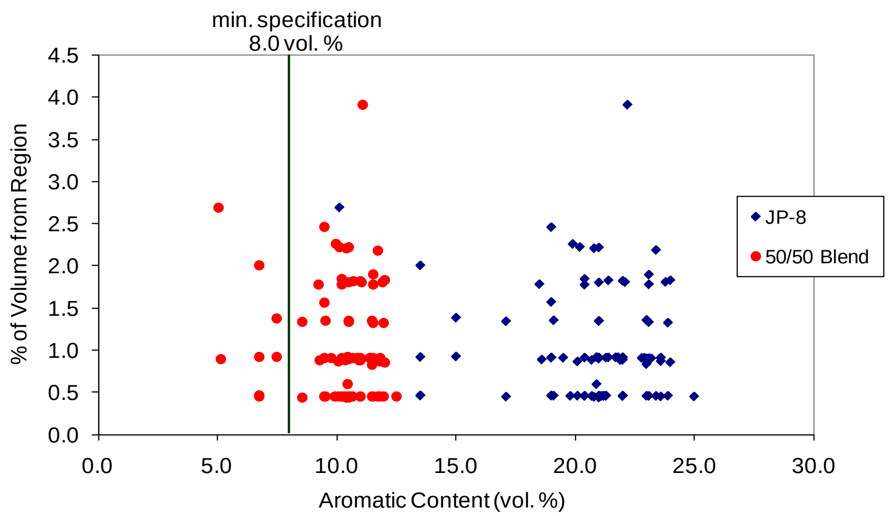

Figure 95. Aromatic Content of JP-8 and 50 vol. % Blend with SPK Based on 2004 PQIS Data from Region 1.

3.2.1.2 Predicted Aromatics of Blend Based on the PQIS Data for Region 2

Table 50 shows the percentage of fuel with an aromatic content below the minimum specification (8.0 vol. %) when blended with 50 vol. % of SPK from the 1997-2008 PQIS Data for Region 2 of CONUS. The high percentages (around 80.0%) shown in Table 50 can be expected from the consistently lower aromatic content of fuel procured in Region 2 as discussed in section 3.1.1.2. In 2001, there was a larger volume of fuel procured with high aromatic content than in other years, resulting in the lower percentage (65.9%) of fuel with aromatic content below 16.0 vol. %.

Table 50. Percent of Fuel with Aromatic Content Below 8.0 vol. % when Blended with 50 vol. % of SPK Based on PQIS Data from Region 2.

Year	Percent Below 8.0 vol. %
1997	88.0
1998	80.3
1999	80.8
2000	83.2
2001	65.9
2002	74.8
2003	78.7
2004	82.4
2005	87.1
2006	83.2
2007	77.1
2008	73.6

Figure 96 shows each individual fuel procurement in Region 2 based on the data from 2008. For each fuel procurement, the aromatic content of the JP-8 fuel as well as the calculated 50/50 blend value and corresponding percent of total volume from Region 2 are shown. As shown, 73.6% of the fuel procured in 2008 from Region 2 has an aromatic content below the minimum blend specification when blended with 50 vol. % of SPK. Due to the large volume of fuel procured in each year from Region 2 with a low aromatic content, the percent of fuel that can be blended with 50 percent SPK without falling below 8.0 vol. % aromatics is around 20.0%.

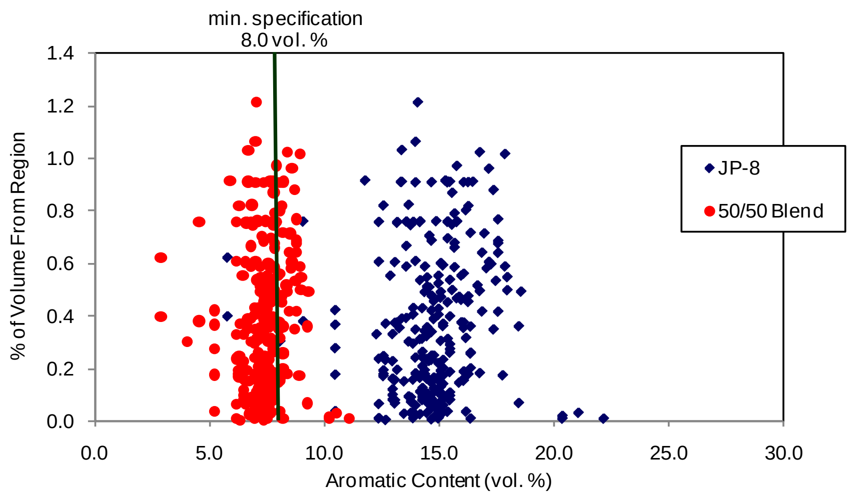

Figure 96. Aromatic Content of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 2.

3.2.1.3 Predicted Aromatics of Blend Based on the PQIS Data for Region 3

Table 51 shows the percentage of fuel with an aromatic content below the minimum specification (8.0 vol. %) when blended with 50 vol. % SPK from the 1997-2008 PQIS Data for Region 3 of CONUS. As discussed in section 3.1.1.3, the aromatic content of fuel procured in Region 3 was within a consistent range for all years. Therefore, the percentages of fuel with aromatic content less than 16.0 vol. % are fairly consistent at about 15.0 vol. % throughout the years 1997-2005. The percentage is slightly higher (about 25.0 vol. %) in the years 2006-2008. The variation in the percentages is due to differing volumes of fuel with low and/or high aromatic content throughout the years.

Table 51. Percent of Fuel with Aromatic Content Below 8.0 vol. % when Blended with 50 vol. % of SPK Based on PQIS Data from Region 3.

Year	Percent Below 8.0 vol. %
1997	18.3
1998	18.9
1999	16.1
2000	10.5
2001	11.6
2002	12.0
2003	13.6
2004	16.6
2005	14.4
2006	25.7
2007	23.7
2008	25.8

Figure 97 shows each individual fuel procurement in Region 3 based on the data from 2008. For each fuel procurement, the aromatic content of the JP-8 fuel as well as the calculated 50/50 blend value and corresponding percent of total volume from Region 3 are shown. As shown, 25.8 % of the fuel procured in 2008 from Region 3 has an aromatic content that falls below the minimum blend specification when blended with 50 percent volume of SPK.

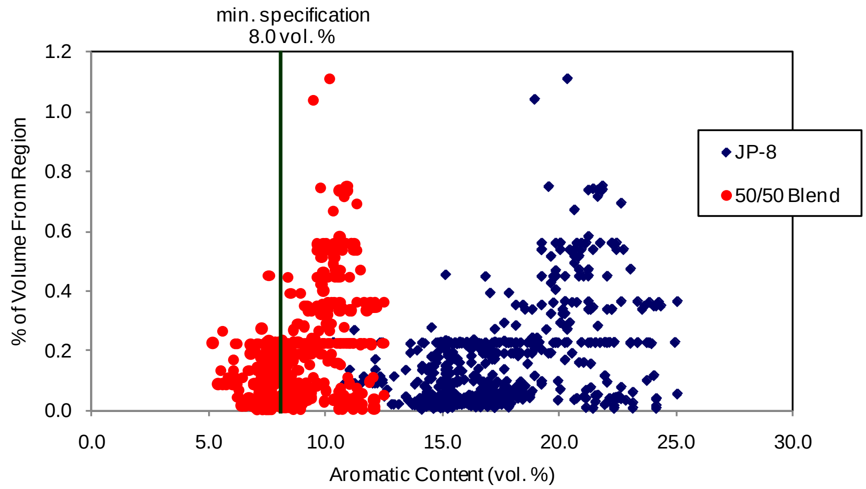

Figure 97. Aromatic Content of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 3.

3.2.1.4 Predicted Aromatics of Blend Based on the PQIS Data for Region 4

Table 52 shows the percentage of fuel with an aromatic content below the minimum specification (8.0 vol. %) when blended with 50 vol. % of SPK from the 1997-2008 PQIS Data for Region 4 of CONUS. As expected from the inconsistencies in the range of aromatic content between the years (section 3.1.1.4), the percentage of fuel procured in Region 4 with aromatic content below 16.0 vol. % is not consistent for all years. The percentage ranges from 37.9 to 67.8% throughout the years 1997-2008. The percentages are also higher than in Region 3 since the weight mean aromatic content is around 16.0 vol. % for all years.

Table 52. Percent of Fuel with Aromatic Content Below 8.0 vol. % when Blended with 50 vol. % of SPK Based on PQIS Data from Region 4.

Year	Percent Below 8.0 vol. %
1997	45.5
1998	56.2
1999	50.4
2000	67.8
2001	54.8
2002	37.1
2003	49.4
2004	40.3
2005	49.2
2006	52.1
2007	37.9
2008	66.8

Figure 98 shows each individual fuel procurement in Region 4 based on the data from 2008. For each fuel procurement, the aromatic content of the JP-8 fuel as well as the calculated 50/50 blend value and corresponding percent of total volume from Region 4 are shown. As shown, 66.8% of the fuel procured in 2008 from Region 4 has an aromatic content that falls below the minimum blend specification when blended with 50 percent volume of SPK.

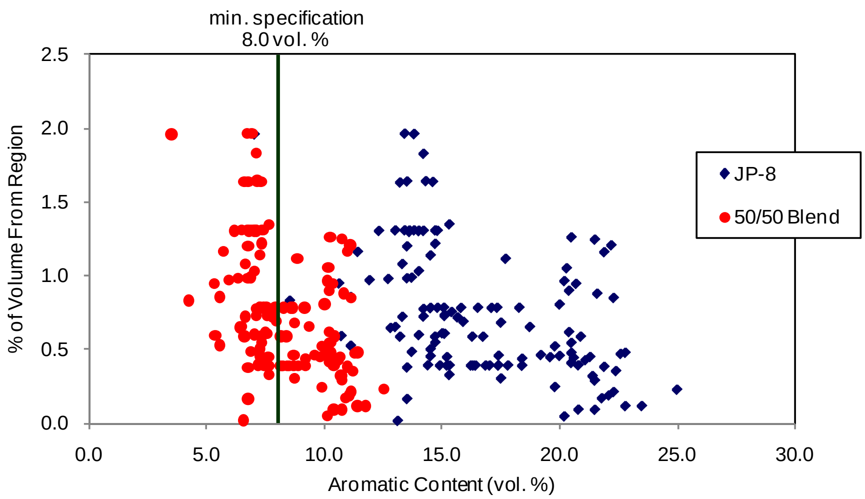

Figure 98. Aromatic Content of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 4.

3.2.1.5 Predicted Aromatics of Blend Based on the PQIS Data for Region 5

Table 53 shows the percentage of fuel with an aromatic content below the minimum specification (8.0 vol. %) when blended with 50 vo. % of SPK from the 1997-2008 PQIS Data for Region 5 of CONUS. Due to the procurement of differing volumes of fuel with low aromatic content between the years, there are inconsistencies in the percentage of fuel with aromatic content below 16.0 vol. %. As discussed in section 3.1.1.5, there were a few fuel procurements in some years in Region 5 with aromatic content below normal specification limits resulting in a higher percentage of fuel below 16.0 vol. %. The percentage is distinctly lower in 2006 and 2007 due to only a few of low volume fuel procurements with an aromatic content below 16.0 vol. % during these years.

Table 53. Percent of Fuel with Aromatic Content Below 8.0 vol. % when Blended with 50 vol. % of SPK Based on PQIS Data from Region 5.

Year	Percent Below 8.0 vol. %
1997	29.4
1998	32.5
1999	16.3
2000	22.6
2001	31.9
2002	28.3
2003	29.4
2004	44.5
2005	25.7
2006	5.3
2007	4.0
2008	15.2

Figure 99 shows each individual fuel procurement in Region 5 based on the data from 2008. For each fuel procurement, the aromatic content of the JP-8 fuel as well as the calculated 50/50 blend value and corresponding percent of total volume from Region 5 are shown. As shown, 15.2 % of the fuel procured in 2008 from Region 5 has an aromatic content that falls below the minimum blend specification when blended with 50 percent volume of SPK.

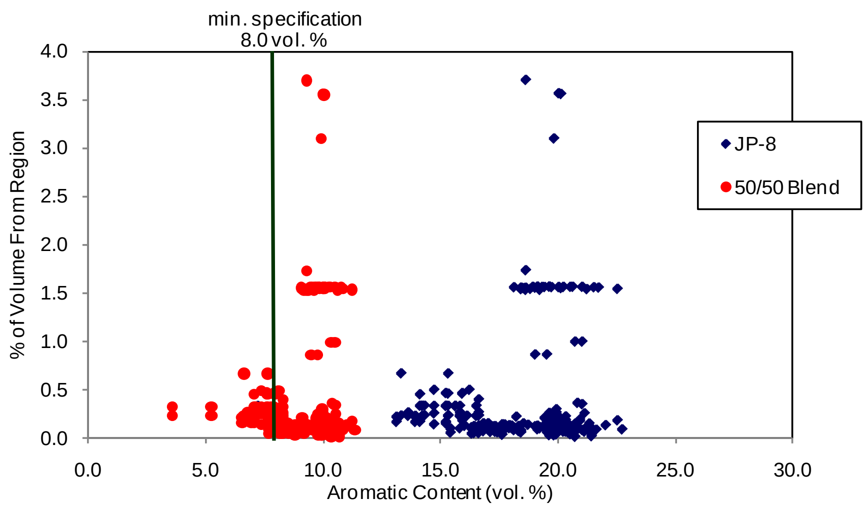

Figure 99. Aromatic Content of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 5.

3.2.1.6 Predicted Aromatics of Blend Based on the PQIS Data for CONUS

Table 54 shows the percentage of fuel with an aromatic content below the minimum specification (8.0 vol. %) when blended with 50 vol. % of SPK from the 1997-2008 PQIS Data for CONUS combined. The percentage of fuel with aromatic content below 16.0 vol. % is relatively consistent for all years in CONUS at approximately 30.0%. Slight variation is due to the procurement of slightly differing volumes of fuel with low aromatic content.

Table 54. Percent of JP-8 Fuel with Aromatic Content Below 8.0 vol. % when Blended with 50 vol. % of SPK Based on PQIS Data from CONUS.

Year	Percent Below 8.0 vol. %
1997	32.9
1998	32.1
1999	25.9
2000	26.8
2001	27.8
2002	25.5
2003	27.0
2004	32.3
2005	26.5
2006	29.4
2007	26.5
2008	29.8

Figure 100 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the aromatic content of the JP-8 fuel as well as the calculated 50/50 blend value and corresponding percent of total volume from CONUS are shown. It is clear that a significant portion of the fuel procurement (and fuel volume) have a total aromatic content below the minimum specification limit. More specifically, 29.8 % of the fuel procured in 2008 from CONUS has an aromatic content that falls below the minimum blend specification when blended with 50 vol. % of SPK. This comprises a significant portion of the total fuel procured and demonstrates considerable probability that a 50 vol. % fuel blend would not meet the requirement for use.

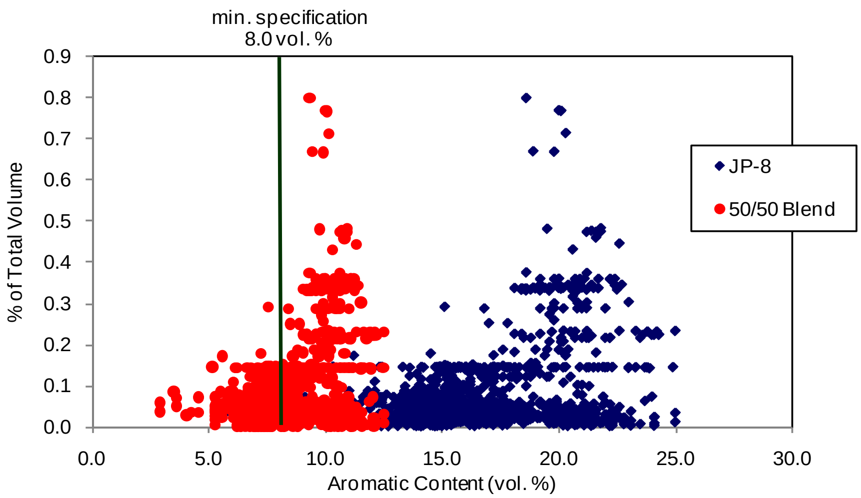

Figure 100. Aromatic Content of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from CONUS.

3.2.1.7 Probability of 50 Vol. % Blend Satisfying Aromatic Requirement

The discrete analyses performed to investigate the percentage of blends which would not satisfy the minimum aromatic concentration (8.0 vol. %) demonstrated there are significant differences based on the region of the procurement. A comparison of the percentage of fuel volume which would be below 8.0 vol. % as a function of year for each region is shown in Figure 101. It is evident that there are significant inconsistencies in the fuel volume which would not satisfy the minimum content between and within each region and CONUS throughout the years. Although analysis of CONUS combined shows there is approximately a 25-35% probability of falling below 8.0%, there is a significant difference in the relative percentages in each region. Although the mean aromatic values were relatively consistent over the time considered (Figure 20), it is evident that shifts in the relative distributions has occurred leading to statistically significant variances. *Therefore, if only the trends were considered in CONUS, the probability of meeting the minimum specification requirement in each region would be significantly over-/underestimated.* Thus each region needs to be considered independently to determine the possibility that a JP-8/SPK 50 vol. % fuel blend from a specific region will have an aromatic content below 8.0 vol. %.

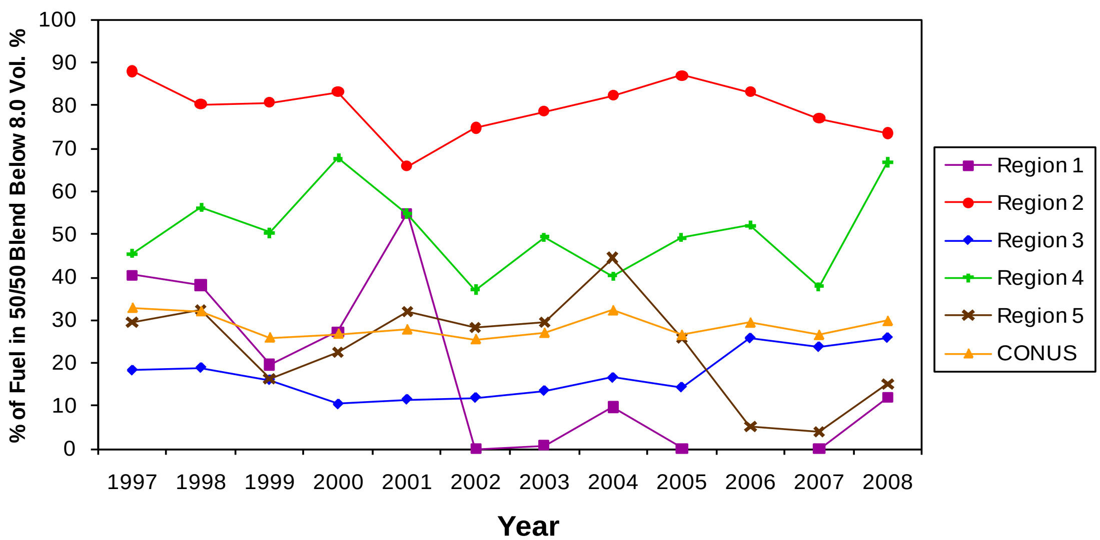

Figure 101. Percent of Fuel from 1997-2008 in 50 vol. % Blend with SPK with Aromatic Content Below 8.0 vol. % for Regions of CONUS.

The percent of JP-8 fuel, when blended with 50 vol. % of SPK, that falls below the minimum specification limit (8.0 vol. %) is not consistent throughout all regions of CONUS. The likelihood fuel procured in Region 1 will have an aromatic content below 8.0 vol. % is statistically higher in the years 1997-2001 than in 2002-2005 and 2007. These inconsistencies are expected from the variations in the aromatic content of fuel procured in each year, as previously discussed. The procurement of one large volume batch of fuel in 2008 with an aromatic content below 16.0 vol. % accounts for the slightly higher percentage in that year. Based on the most recent historical data, approximately 10.0% (or less) of blends procured in Region 1 will not meet the specification. This is much better than the CONUS average, but the fuel in this region comprises a very small percent (< 1%) of total fuel procured. Conversely, approximately 80% of the fuel volume procured in Region 2 will have an aromatic content below 8.0 vol. % when blended with 50 vol. % of SPK. This could be extremely problematic when attempting to implement the use of SPK as a blend feedstock. Supplemental analyses shown in Appendix A using the 2008 PQIS data indicated that the maximum blend percentage allowable in Region 2 to allow 95% of the fuel volume to meet 8.0% aromatic content is 23.8% (maximum blend percentages of 35.0% and 38.5% for 90 and 80% of total fuel volume to meet specification). The cause of the substantially low aromatic content of fuel procured in Region 2 is not readily apparent. Analysis of Region 3 indicates there is a slightly improved chance (~25%) a fuel blend will fall below 8.0% relative to CONUS, but was better (only ~15%) before 2005. This shift to lower probability is not evident when only considering the mean values (Figure 20). As expected from the inconsistencies in the range of aromatic content between the years, the percentage of fuel procured in Region 4 with aromatic content below 16.0% shows substantial variability. The percentage ranges from 37.9 to 67.8% throughout the years studied. This probability is much higher than in CONUS combined, which could be problematic during implementation. Region 5 showed a significant probability of falling below 8.0% for years 1997-2005 (~30%), but has improved substantially in recent years (~10-15%).

Based on the trends observed and analysis, a basic projection of the volume percent of fuels which would have an aromatic content below 16.0% (50% blend content below 8.0%) was made and is shown in Table 55. With the exception of Region 4, there is a relatively consistent percentage of the fuel volume within each region with an aromatic content which would not meet the minimum specification requirement when blended with SPK. The percentage in Region 4 was inconsistent throughout all years, although still higher than most of the other regions. **Overall, based on the analysis of the aromatic content of fuel procured in individual Regions 1-5 and CONUS combined, there are statistical differences in the percentage of 50 vol. % blends which would not satisfy the JP-8/SPK specification requirements. The prediction of the aromatic content of 50 vol. % blends based solely on the trends for CONUS combined would produce a statistically inaccurate estimation of the percentage of fuel with aromatic content below 16.0 vol. % for each region. Therefore, consideration must be made during implementation of blending JP-8 with SPK regarding the possibility that a fuel blend will have an insufficient aromatic content to meet the minimum requirement and the probability will vary based on Region of procurement.** Further research and development should be performed to determine if the minimum aromatic content for a fuel blend could be reduced while maintaining safe operability and satisfying all Fit-for-Purpose requirements. A lower specification limit would significantly increase the maximum allowable percentage of SPK which could be blended with a specific JP-8 and decrease the probability that a 50 vol. % blend will not satisfy the requirement.

Table 55. Trends in Percent of Fuel with Aromatic Content Below 16.0 vol. % from 1997-2008.

Region	% of Fuel
1	<10.0*
2	80.0
3	20.0
4	37.9 - 67.8**
5	30.0
CONUS	30.0

* Consistent over last six years, allowing for future predictions
** Not consistent for consecutive years, cannot be predicted

3.2.2 Density of JP-8/SPK Blends

The following sections discuss analyses which were performed to calculate the percent of the total fuel volume procured, when blended with 50 vol. % of SPK, that would not satisfy the minimum blend specification limit for fuel density of 0.775 g/mL. The analyses were performed as a function of both year and region using the PQIS data from 1999-2008 to determine if consistent trends exist and to indentify anticipated future trends. It was assumed that the SPK has a density of 0.751 g/mL, which is the minimum allowable density for the SPK per the military fuel specification (see Table A-I of MIL-DTL-83133F). Use of the minimum allowable density value allows for the most conservative estimate of the volume percentage which will not meet the required minimum blend density; SPK with a higher neat density will result in less frequency below the minimum value. In order to remain above the minimum specification limit when blending with 50 percent volume of SPK (minimum density of 0.751 g/mL), the original JP-8 fuel must have a density of at least 0.799 g/mL. The commercial specification allows for the SPK to have a lower minimum density of 0.730 g/mL (see Table A1.1 of ASTM D7566-09), which will potentially decrease the probability that a 50 vol. % fuel blend will not meet the minimum density specification. As during the discussion of the resulting aromatic content during blending, the analysis was performed using the discrete PQIS data and the reported values are based completely on the actual fuel properties/volumes procured from 1999-2008. The mean density values shown in Figure 34 were useful in understanding general trends, but do not represent the breadth of the data (see Table 16 and Figure 35). If only the mean values are considered, it is possible to erroneously assume the majority of the fuel blends, with the exception of Region 1, will satisfy the minimum requirement since the mean values were all greater than 0.799 g/mL. In the following sections, the percent of total fuel volume within the region for a specific year is plotted as a function of the PQIS density of the fuel in addition to the calculated density of a 50 vol. % SPK blend. The minimum specification limit for a blend of JP-8 and SPK (0.775 g/mL) is labeled on the figures to demonstrate the frequency of fuel procurements that would not satisfy the minimum limit. The data from 2008 is plotted in these figures for Regions 2-5 and CONUS combined to demonstrate the most recent trends. The data from 2004 is plotted for Region 1 due to the small amount of fuel procured in 2005, 2007, and 2008 and the lack of fuel procured in 2006 in Region 1.

3.2.2.1 Predicted Density of Blend Based on the PQIS Data for Region 1

Table 56 shows the percentage of fuel with a density below the minimum specification (0.775 g/mL) when blended with 50 percent volume of SPK (minimum density of 0.751 g/mL) from the 1999-2005 and 2007-2008 PQIS Data for Region 1 of CONUS. The differing percentages, shown in Table 56, can be expected from the inconsistencies between years discussed in section 3.1.2.1. The number of fuel procurements and volume of fuel with a density below 0.799 g/mL is not consistent throughout all years in Region 1. The percentages are distinctly lower (0.0-6.6%) in the years 2002-2004 due to few or no fuel procurements with density lower than 0.799 g/mL. On the contrary, the percentage in 2005, 2007, and 2008 (92.9%, 96.2% and 100.0%) are the result of large volume fuel procurements with low density and few low volume procurements with higher density during this year. Due to the low number and volume of fuel procurements in 2005, 2007, and 2008, the percentage of 50 vol. % blends with density below 0.775 g/mL is not representative of what is to be expected in Region 1.

Table 56. Percent of Fuel with Density Below 0.775 g/mL when Blended with 50 vol. % of SPK Based on PQIS Data from Region 1.

Year	Percent Below 0.775 g/mL
1999	23.7
2000	12.4
2001	3.2
2002	—
2003	—
2004	6.6
2005	92.9
2007	96.2
2008	100.0

Figure 102 shows each individual fuel procurement in Region 1 based on the data from 2004. For each fuel procurement, the density of the JP-8 fuel as well as the calculated 50 vol. % blend value and corresponding percent of total volume from Region 1 are shown. As shown in, 6.6 % of the fuel procured in 2004 from Region 1 has a density that falls below the minimum blend specification when blended with 50 percent volume of SPK.

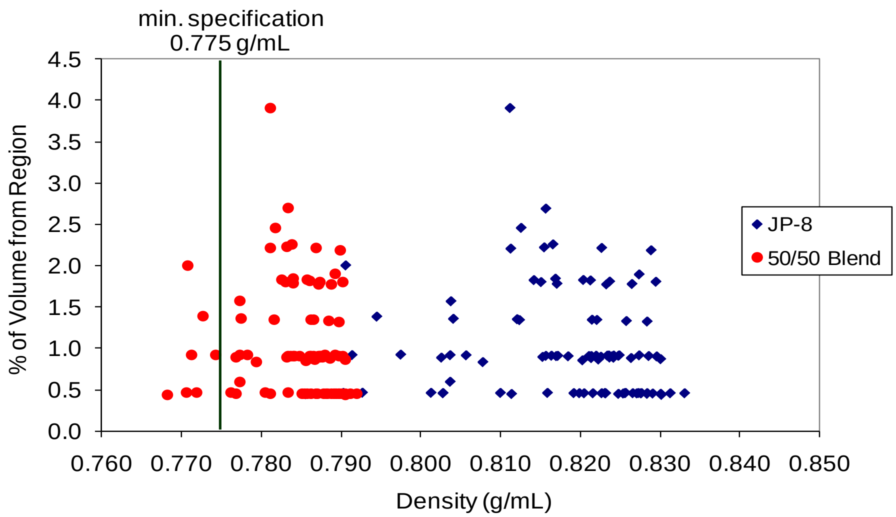

Figure 102. Density of JP-8 and 50 vol. % Blend with SPK Based on 2004 PQIS Data from Region 1.

3.2.2.2 Predicted Density of Blend Based on the PQIS Data for Region 2

Table 57 shows the percentage of fuel with a density below the minimum specification (0.775 g/mL) when blended with 50 vol. % of SPK from the 1999-2008 PQIS Data for Region 2 of CONUS. Despite the consistent weight means and confidence intervals throughout the years in Region 2 (section 3.1.2.2), there is a shift in the percentage of fuel with density below 0.799 g/mL. The percentage is higher in 2001-2003 than in other years due to a larger volume of fuel procured in these years with a low density.

Table 57. Percent of Fuel with Density Below 0.775 g/mL when Blended with 50 vol. % of SPK Based on PQIS Data from Region 2.

Year	Percent Below 0.775 g/mL
1999	1.1
2000	1.9
2001	10.1
2002	8.3
2003	9.6
2004	3.3
2005	0.6
2006	0.8
2007	—
2008	4.1

Figure 103 shows each individual fuel procurement in Region 2 based on the data from 2008. For each fuel procurement, the density of the JP-8 fuel as well as the calculated 50 vol. % blend value and corresponding percent of total volume from Region 2 are shown. As shown, 4.1% of the fuel procured in 2008 from Region 2 has a density that falls below the minimum blend specification when blended with 50 vol. % of SPK.

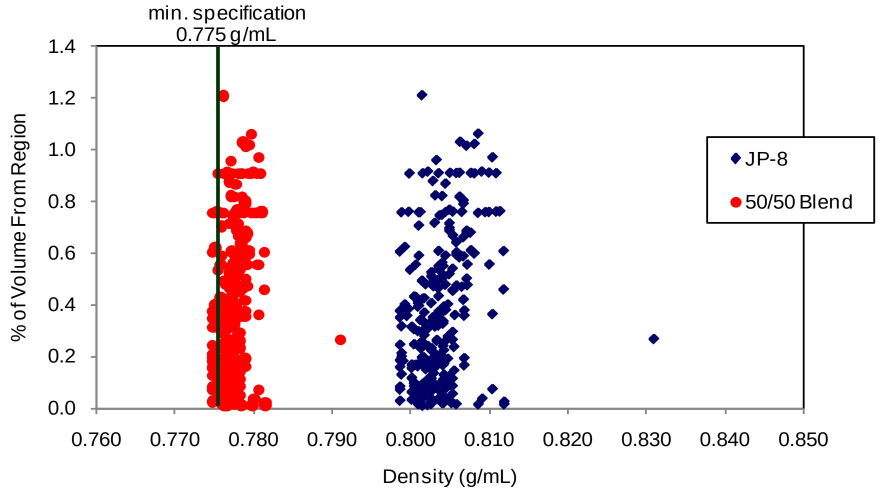

Figure 103. Density of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 2.

3.2.2.3 Predicted Density of Blend Based on the PQIS Data for Region 3

Table 58 shows the percentage of fuel with a density below the minimum specification (0.775 g/mL) when blended with 50 vol. % of SPK from the 1999-2008 PQIS Data for Region 3 of CONUS. Despite consistent mean densities and confidence intervals in Region 3 (section 3.1.2.3), the percentage of fuel with density below 0.799 g/mL is not consistent for all years. The percentage is consistently about 30.0% in the years 2000-2001 and 2005-2008. However, in 1999 and 2004, the percentage is higher (about 40.0%) due to a lower volume of fuel with high density procured in these years. The percentages are lower in 2002 and 2003 at 13.5% and 16.3% since a lower volume of was procured with a low density during these years.

Table 58. Percent of Fuel with Density Below 0.775 g/mL when Blended with 50 vol. % of SPK Based on PQIS Data from Region 3.

Year	Percent Below 0.775 g/mL
1999	39.3
2000	31.3
2001	28.8
2002	13.5
2003	16.3
2004	42.8
2005	30.1
2006	24.5
2007	28.6
2008	32.3

Figure 104 shows each individual fuel procurement in Region 3 based on the data from 2008. For each fuel procurement, the density of the JP-8 fuel as well as the calculated 50 vol. %

blend and corresponding percent of total volume from Region 3 are shown. As shown, 32.3 % of the fuel procured in 2008 from Region 3 has a density that falls below the minimum blend specification when blended with 50 percent volume of SPK.

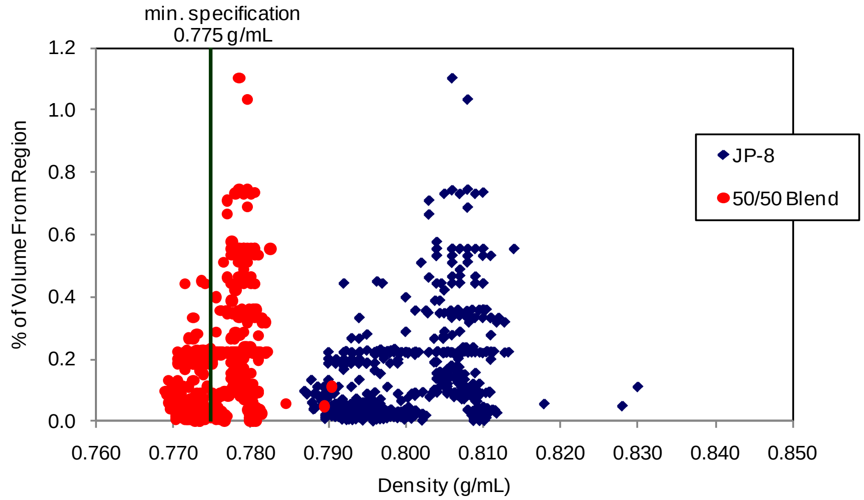

Figure 104. Density of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 3.

3.2.2.4 Predicted Density of Blend Based on the PQIS Data for Region 4

Table 59 shows the percentage of fuel with a density below the minimum specification (0.775 g/mL) when blended with 50 vol. % of SPK from the 1999-2008 PQIS Data for Region 4 of CONUS. As expected by the inconsistencies in the confidence intervals in Region 4 (section 3.1.2.4), the percentage of fuel with density below 0.799 g/mL varies throughout the years. In 2000 and 2006, there was a larger volume of fuel procurements with low density and only a few procurements with high density resulting in the higher percentages shown in Table 59. The percentage is lower in 2004 (9.1%) since only a small volume of fuel was procured with density lower than 0.799 g/mL in that year.

Table 59. Percent of Fuel with Density Below 0.775 g/mL when Blended with 50 vol. % of SPK Based on PQIS Data from Region 4.

Year	Percent Below 0.775 g/mL
1999	33.6
2000	45.5
2001	22.2
2002	23.6
2003	17.3
2004	9.1
2005	37.0
2006	41.6
2007	35.8
2008	30.0

Figure 105 shows each individual fuel procurement in Region 4 based on the data from 2008. For each fuel procurement, the density of the JP-8 fuel as well as the calculated 50 vol. % blend value and corresponding percent of total volume from Region 4 are shown. As shown, 30.0% of the fuel procured in 2008 from Region 4 has a density that falls below the minimum blend specification when blended with 50 percent volume of SPK.

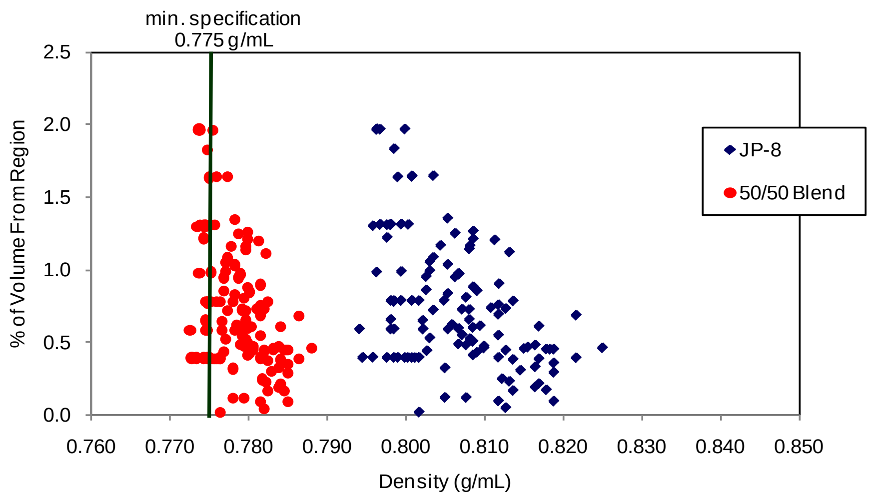

Figure 105. Density of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 4.

3.2.2.5 Predicted Density of Blend Based on the PQIS Data for Region 5

Table 60 shows the percentage of fuel with a density below the minimum specification (0.775 g/mL) when blended with 50 vol. % of SPK from the 1999-2008 PQIS Data for Region 5 of CONUS. As discussed in section 3.1.2.7, the fuel procured in Region 5 had a consistently higher density than in any other region. Therefore, the extremely low percentage of fuel with density below 0.799 g/mL was expected.

Table 60. Percent of Fuel with Density Below 0.775 g/mL when Blended with 50 vol. % of SPK Based on PQIS Data from Region 5.

Year	Percent Below 0.775 g/mL
1999	—
2000	0.7
2001	—
2002	—
2003	—
2004	—
2005	1.9
2006	—
2007	—
2008	—

Figure 106 shows each individual fuel procurement in Region 5 based on the data from 2008. For each fuel procurement, the density of the JP-8 fuel as well as the calculated 50 vol. % blend value and corresponding percent of total volume from Region 5 are shown. As shown, there was no fuel procured in 2008 from Region 5 with a density that falls below the minimum blend specification when blended with 50 vol. % of SPK.

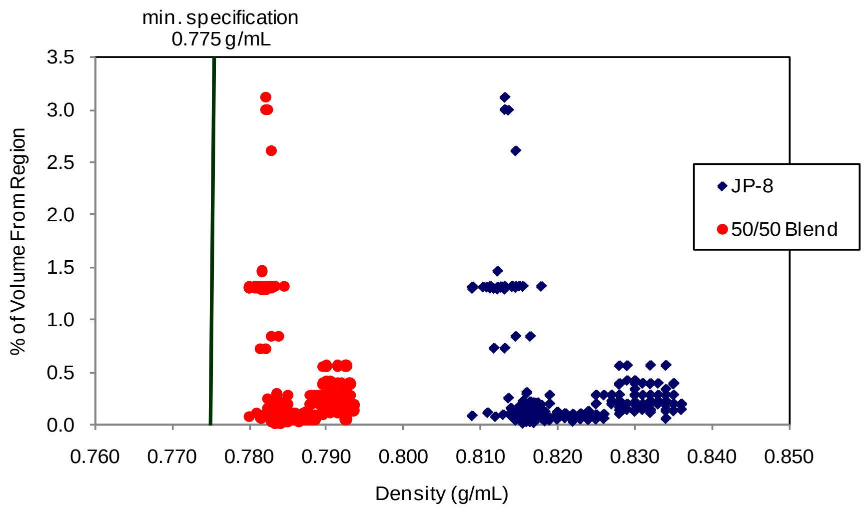

Figure 106. Density of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from Region 5.

3.2.2.6 Predicted Density of Blend Based on the PQIS Data for CONUS

Table 61 shows the percentage of fuel with a density below the minimum specification (0.775 g/mL) when blended with 50 vol. % of SPK from the 1999-2008 PQIS Data for CONUS combined. Despite consistent mean densities and confidence intervals (section 3.1.2.6), there are statistical differences in the percent of fuel procured in CONUS with density below 0.799 g/mL. The percentage is approximately 20.0% in 2000-2001 and 2005-2008. However in 2002 and 2003 the percentages are lower at 10.2% and 12.1% due to a larger volume of fuel procured with a high density during these years, lowering the percentage of low density fuel. On the contrary, in 1999 and 2004, there were a number of large volume fuel procurements with low density, resulting in the higher percentages of about 26.5%. It should be reiterated that the estimates for the percent of fuels which will not satisfy the requirement for CONUS are conservative and will be reduced if the SPK has a higher density; however, typical density values for SPKs investigated thus far have been shown to have values which are both higher and lower than 0.751 g/mL.[9]

Table 61. Percent of Fuel with Density Below 0.775 g/mL when Blended with 50 vol. % of SPK Based on PQIS Data from CONUS.

Year	Percent Below 0.775 g/mL
1999	26.5
2000	20.9
2001	18.8
2002	10.2
2003	12.1
2004	26.4
2005	21.5
2006	17.6
2007	19.2
2008	21.8

Figure 107 shows each individual fuel procurement in CONUS based on the data from 2008. For each fuel procurement, the density of the JP-8 fuel as well as the calculated 50 vol. % blend value and corresponding percent of total volume from CONUS are shown. As shown in Figure 107, 21.8% of the fuel procured in 2008 from CONUS has a density that falls below the minimum blend specification when blended with 50 percent volume of SPK.

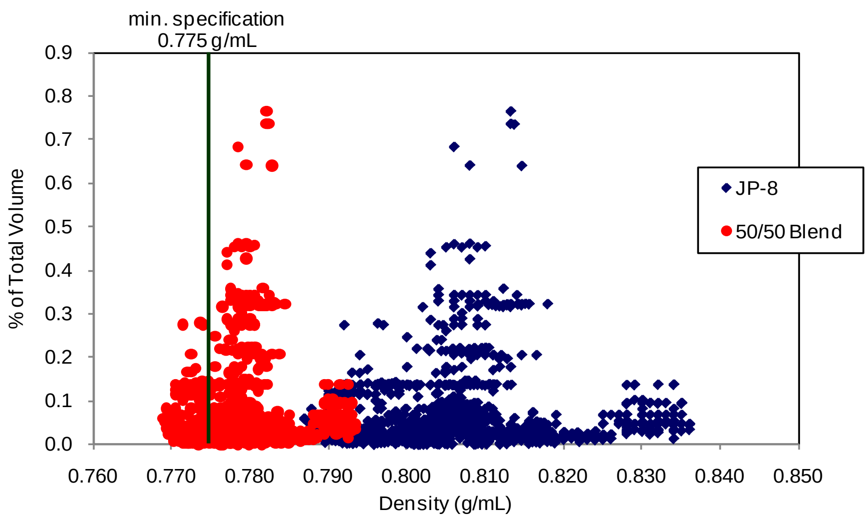

Figure 107. Density of JP-8 and 50 vol. % Blend with SPK Based on 2008 PQIS Data from CONUS.

3.2.2.7 Probability of 50 Vol. % Blend Satisfying Density Requirement

The discrete analyses performed to investigate the percentage of blends which would not satisfy the minimum density value (0.775 g/mL) demonstrated there are significant differences based on the region of procurement. A comparison of the percentage of fuel volume which would be below 0.775 g/mL as a function of year for each region is shown in Figure 108. There are clear differences in the probability that a fuel blend density will be too low depending on the region in which the JP-8 was procured. In addition, with the exception of Region 5, there has been significant variability in the trends as a function of time. These results indicate that although the mean density has been relatively consistent (Figure 34), shifts in the density distributions result in statistically significant alterations in the trends. *Therefore, it is required that the location of procurement be considered when attempting to determine the probability that a 50 vol. % fuel blend will meet the density specification.*

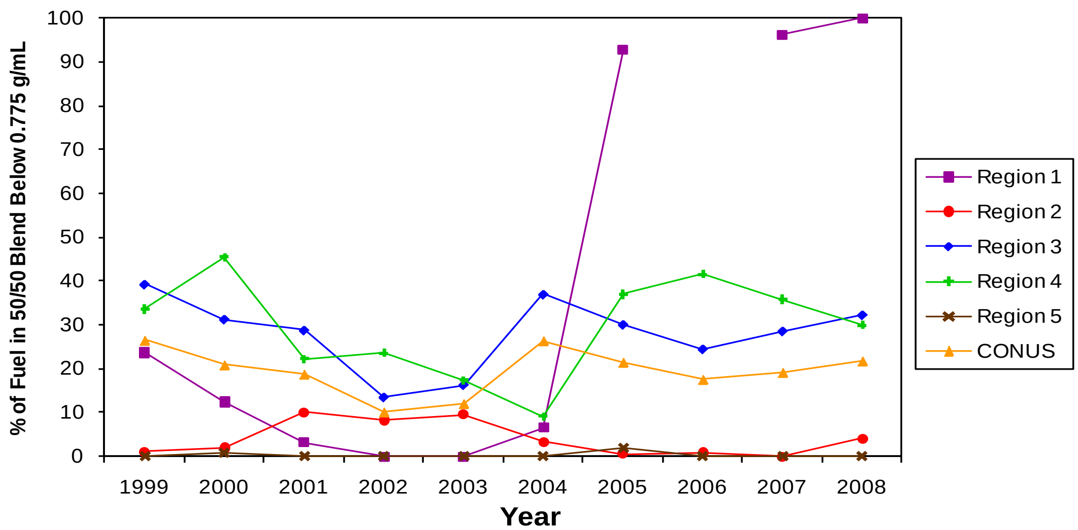

Figure 108. Percent of Fuel from 1999-2008 in 50 vol. % Blend with SPK with Density Below 0.775 g/mL for Regions of CONUS.

The percent of JP-8 fuel, when blended with 50 vol. % of SPK with a density of 0.751 g/mL, which will not satisfy the minimum specification limit (0.775 g/mL) is not consistent throughout all regions of CONUS. Region 1 showed a significant shift in recent years to almost a complete probability that the blend density will be below the minimum limit. However, as previously discussed, the total volume of fuel procured in Region 1 has been extremely low. The percentages in Region 2 and 5 are extremely low, due to the procurement of a small volumes of fuel with a density below 0.799 g/mL. This can be observed by review of the relative distributions shown in Figure 35. It is clear for Region 5 that fuels procured have a much higher relative density than in other regions, which is also shown by the much higher mean density value (Figure 34 and Table 16). The result for Region 2, especially compared to that for Region 3, is somewhat surprising considering the mean density value trends shown in Figure 34. Although the mean densities for these regions are similar, the analysis indicates that the density range is narrower for Region 2 (see Table 15). The results for Region 2 are somewhat surprising as the preceding analysis showed very high percentages of the fuels would not meet the minimum aromatic content. This further demonstrates that other fuel characteristics must more strongly affect the fuel density than aromatic content alone. Overall, fuel procured in Regions 2 and 5 will have a very high probability that the blend density will meet the minimum specification limit.

Despite consistent mean densities in Region 3, the percentage of fuel with density below 0.799 g/mL has varied over recent years. The percentage is consistently about 30.0% in the years 2000-2001 and 2005-2008. However, in 1999 and 2004, the percentage is higher (approximately 40.0%) due to a lower volume of fuel with high density procured in these years. The percentages are lower in 2002 and 2003 at 13.5% and 16.3% since a lower volume of fuel was procured with a low density during these years. Based on the most recent years, the probability that a 50 vol. % blend from Region 3 will have a density below the minimum specification is consistently about 30.0%. This is higher than that for CONUS, which is approximately 20%. This higher probability is important to consider as the largest annual volume of fuel is procured in Region 3, and could result in significant chance that a fuel blend will not satisfy the minimum specification. An alternative approach is to calculate the maximum blend percentage that can be used while still meeting the specification requirement. Supplemental analyses using the 2008 PQIS data shown in Appendix A using the 2008 PQIS data indicated that the maximum blend percentages for 95, 90 and 80% of the total fuel volume to satisfy the specification limit were 38.5, 41.5, and 42.9%, respectively. These blend percentages are below the maximum allowable 50%. On the contrary, Region 5 showed much higher blend percentages, 58.6 (for 95% of fuel volume), 59.3 (90%) and 60.7% (80%), could be used while still meeting the specification. <u>This type of approach may be necessary during implementation since the minimum property specification limits must always be met.</u> The probability that the density for Region 4 will be below 0.799 g/mL has not been consistent for more than three consecutive years, and has ranged from 9.1 to 45.5%. This makes it difficult to predict the future probability that a fuel blend will not meet the minimum specification.

Based on the trends observed and analysis, an estimation of the volume percent of fuel blends which would have a density below 0.775 g/mL (using SPK with density of 0.751 g/mL) was performed and is shown in Table 62. During recent years, there is a relatively consistent volume of fuel within each region which would not meet the minimum specification limit. The percentage in Region 4, as during the aromatic analysis, was inconsistent, but higher than other regions in recent years. Region 5 showed that almost all fuels procured will meet the density requirement, but the lower density values in Region 3 result in the CONUS average of approximately 20%. <u>*Overall, it is important to consider the region from which fuel is procured during implementation of blending with SPK when estimating the probability that a 50/50 blend will have a density below the minimum specification limit.*</u>

Overall, based on the analysis of the density of fuel procured in individual Regions 1-5 and CONUS combined, there are statistical differences in the percentage of 50 vol. % blends which would not satisfy the JP-8/SPK specification requirements. The prediction of the density of 50 vol. % blends based solely on the analysis of CONUS combined would produce a statistically inaccurate estimation of the percentage of fuel with density below 0.799 g/mL for each region. <u>Therefore, consideration must be made during</u>

implementation of blending JP-8 with SPK regarding the possibility that a fuel blend will have a density which does not meet the minimum requirement which is dependent on the region of CONUS in which the JP-8 fuel is procured. Further research and development efforts related to determining the potential for safe aircraft operation with a lower minimum density would be beneficial. This would allow for the implementation of higher blend percentages of SPK to be implemented.

Table 62. Trends in Percent of Fuel with Density Below 0.775 g/mL from 1999-2008.

Region	% of Fuel
1	<10.0*
2	<10.0
3	30.0*
4	9.1 - 45.5**
5	<2.0
CONUS	20.0
* Consistent in most recent and relevant years, allowing for future predictions ** Not consistent for consecutive years, cannot be predicted	

4. Summary

There has been continued interest in the use of alternatively-derived (non-petroleum) fuels for aviation applications. In recent years, the use of Synthetic Paraffinic Kerosene (SPK) produced via the Fischer-Tropsch (FT) process has received significant attention. Extensive laboratory and in-field research and development resulted in the recently modified JP-8 military (MIL-DTL-83133F) and Jet A/A-1 commercial (ASTM D7566-09) fuel specifications, which allow blending up to 50 vol. % SPK with certification fuels provided the fuel blend specification requirements are satisfied. Understanding of the implications of the historical variability in selected JP-8 properties helps to identify potential logistical and application issues during implementation. In this effort, detailed analyses were performed using the Petroleum Quality Information System (PQIS) database reported annually by the Defense Energy Support Center (DESC) to investigate the historical variability of selected JP-8 fuel properties from 1997-2008 as a function of the region within the Continental United States (CONUS) in which the fuel was procured. The specific properties studied were: Aromatic Content, Density, Freeze Point, Viscosity, Heat of Combustion (by mass), and the Volumetric Heating Value. Statistically significant differences in both the mean property values and confidence intervals were found to exist based on procurement location for all properties considered except Heat of Combustion (by mass); these differences indicate that it is necessary to consider each CONUS region individually when estimating the expected fuel properties during blending with SPK. Use of the average CONUS property values and historical variability would result in a significant under-/overestimation of each respective property value depending upon the region in which the fuel was procured. Consistent historical trends were observed for several properties within specific regions, which allows for prediction of expected fuel properties in the future. Analyses were performed to determine if correlations exist between any of the JP-8 properties considered in this study. Specific positive and negative correlations were found for certain properties. An interesting observation was the lack of a correlation between the measured aromatic content and density values.

Calculations using the discrete JP-8 data reported in the PQIS database were performed to determine the probability that the minimum aromatic content or density values would not be satisfied during blending with SPK. The historical variance and differences in these properties as a function of region prevents unconditional implementation of the 50 vol. % maximum blend ratio while still satisfying the minimum 8.0 vol. % aromatic content or 0.775 g/mL density specification requirements. Specific regions were identified where the maximum allowable blend percentage is substantially lower than 50 vol. % to meet the minimum aromatic and density requirements. Conversely, regions were also identified in which the neat JP-8 property is sufficiently high, such as the high density values in Region 5 of CONUS, to allow for increased SPK blend percentages. The analyses reiterated the finding that solely using the historical CONUS aromatic and density values and variability would result in substantial probability that a fuel blend would not satisfy the specification requirements depending on region of procurement. Overall, these analyses provide an initial basis of evaluation for the implementation of alternative fuel blends and the expected maximum volume percentages which can be safely employed.

5. Acknowledgements

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7. Appendix A: Supplemental Statistical Analyses and Estimations of Maximum Allowable SPK Blend Percentages

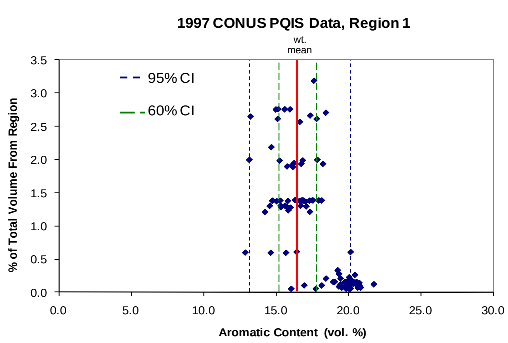
7.1 Aromatic Content

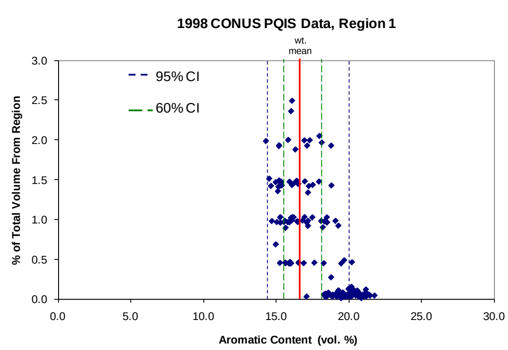
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 1 Based on PQIS Data from 1997-2008.

Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1997	16.4	1.54	(13.2, 20.1)	(13.3, 19.1)	(14.7, 18.2)	(15.0, 17.9)	(15.2, 17.7)
1998	16.6	1.44	(14.5, 20.0)	(14.7, 19.3)	(15.1, 18.6)	(15.2, 18.2)	(15.3, 18.0)
1999	17.3	1.94	(13.8, 21.3)	(14.3, 20.7)	(14.9, 19.4)	(15.5, 19.3)	(16.0, 19.0)
2000	16.7	1.62	(14.2, 21.7)	(14.6, 19.9)	(15.0, 18.8)	(15.3, 17.8)	(15.6, 17.7)
2001	16.7	2.46	(13.4, 22.3)	(13.4, 21.7)	(14.4, 20.4)	(14.8, 19.9)	(14.8, 18.3)
2002	20.8	1.15	(18.9, 22.4)	(19.3, 22.4)	(19.4, 22.3)	(19.8, 22.2)	(19.8, 22.0)
2003	20.6	1.65	(17.3, 23.5)	(18.0, 23.4)	(18.7, 22.9)	(19.2, 22.3)	(19.7, 21.6)
2004	20.6	3.09	(10.1, 24.0)	(13.5, 23.9)	(17.1, 23.4)	(19.0, 23.1)	(19.1, 23.0)
2005	18.8	1.20	(17.5, 20.4)	(17.5, 20.4)	(17.5, 20.4)	(17.5, 20.4)	(17.5, 20.4)
2007	18.4	0.61	(17.0, 19.2)	(17.0, 19.0)	(17.8, 18.9)	(17.8, 18.8)	(17.8, 18.8)
2008	17.7	2.18	(12.1, 18.9)	(12.1, 18.9)	(12.1, 18.9)	(16.8, 18.8)	(17.6, 18.8)

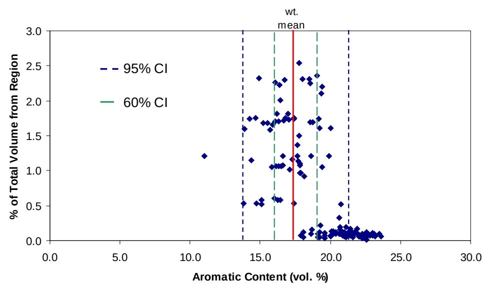
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 1 Based on the Lognormal Distribution of PQIS Data from 1997-2008.

Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1997	1.51	(13.6, 19.5)	(14.0, 19.0)	(14.5, 18.4)	(14.9, 18.0)	(15.1, 17.7)	0.992
1998	1.47	(14.5, 20.2)	(14.7, 19.3)	(15.0, 18.5)	(15.2, 18.0)	(15.4, 17.6)	0.992
1999	1.92	(13.6, 21.1)	(14.2, 20.5)	(14.9, 19.8)	(15.3, 19.3)	(15.7, 18.9)	0.993
2000	1.52	(14.1, 20.1)	(14.5, 19.4)	(14.9, 18.7)	(15.2, 18.3)	(15.4, 17.9)	0.983
2001	2.50	(13.6, 23.1)	(13.8, 21.4)	(14.2, 19.9)	(14.5, 18.9)	(14.7, 18.3)	0.979
2002	1.11	(18.7, 23.1)	(19.1, 22.7)	(19.5, 22.3)	(19.7, 22.0)	(19.9, 21.8)	0.972
2003	1.44	(17.9, 23.5)	(18.3, 23.0)	(18.8, 22.5)	(19.2, 22.1)	(19.4, 21.9)	0.979
2004	3.00	(14.7, 26.4)	(15.6, 25.5)	(16.7, 24.4)	(17.4, 23.6)	(18.0, 23.0)	0.961
2005	1.08	(16.7, 20.9)	(17.0, 20.6)	(17.4, 20.2)	(17.7, 19.9)	(17.9, 19.7)	0.919
2007	0.54	(17.3, 19.4)	(17.5, 19.3)	(17.7, 19.1)	(17.8, 18.9)	(17.9, 18.8)	0.963
2008	1.59	(14.6, 20.9)	(15.1, 20.4)	(15.7, 19.8)	(16.1, 19.4)	(16.4, 19.1)	0.730





1999 CONUS PQIS Data, Region 1



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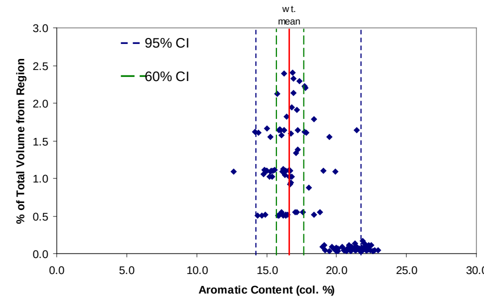

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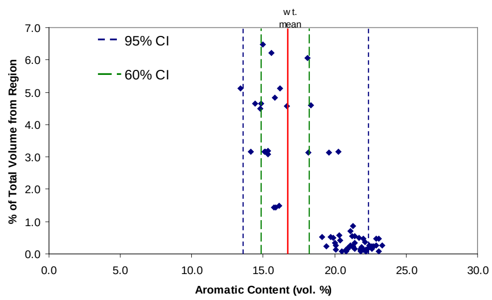

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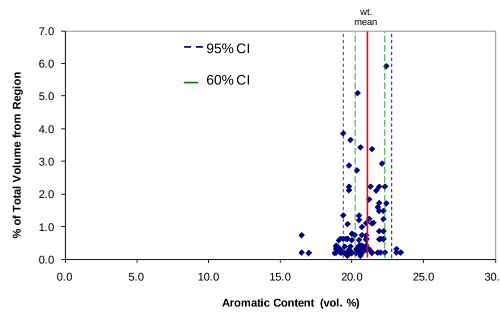
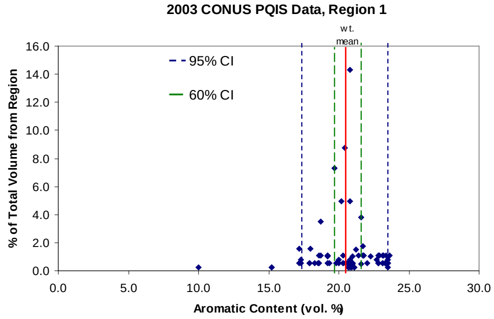


2003 CONUS PQIS Data, Region 1



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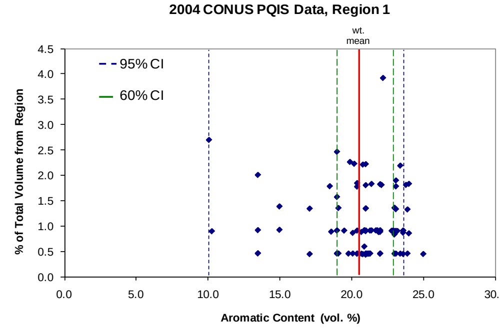

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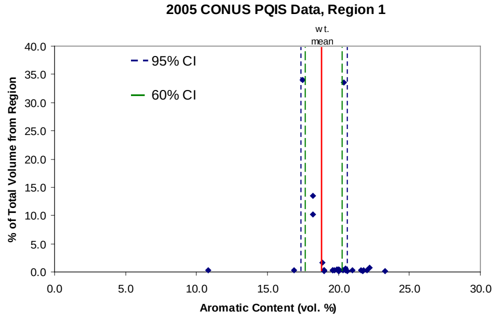
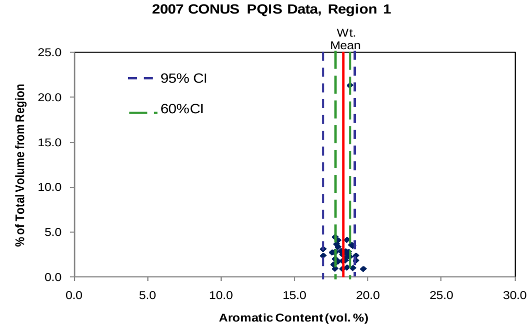
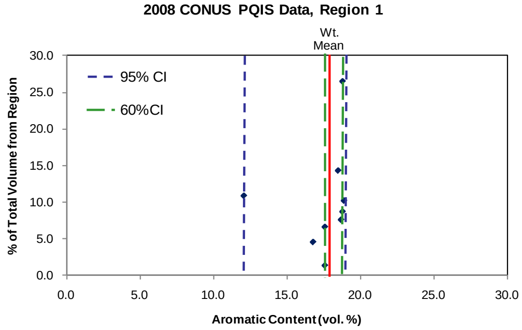


2007 CONUS PQIS Data, Region 1



2008 CONUS PQIS Data, Region 1

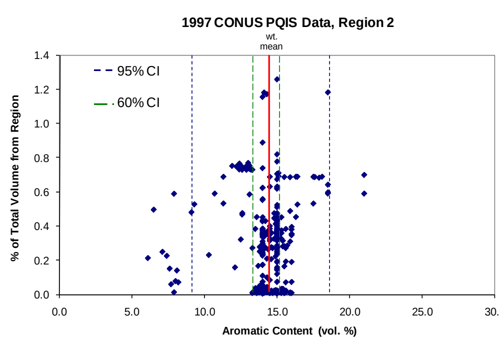


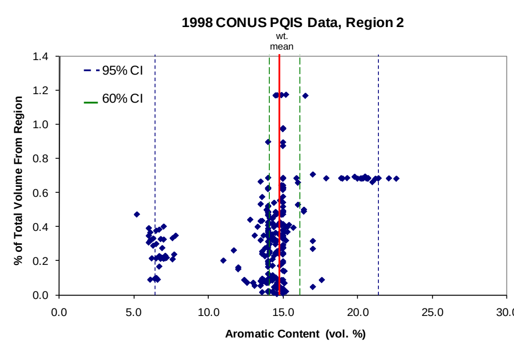
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 2 Based on PQIS Data from 1997-2008.

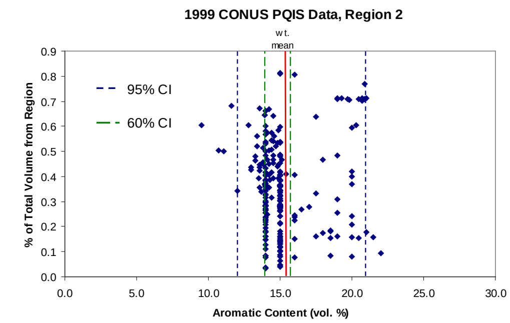
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1997	14.4	1.99	(9.1, 18.5)	(11.3, 18.1)	(12.5, 16.3)	(12.9, 15.5)	(13.3, 15.0)
1998	14.8	3.44	(6.2, 21.4)	(6.7, 20.7)	(11.7, 20.3)	(13.6, 17.9)	(14.0, 15.9)
1999	15.3	2.23	(12.0, 20.9)	(13.3, 18.0)	(13.8, 19.8)	(14.0, 18.5)	(14.0, 15.4)
2000	15.0	1.68	(12.9, 21.4)	(13.0, 18.0)	(13.5, 16.0)	(13.6, 16.0)	(14.0, 15.1)
2001	15.6	2.61	(11.7, 22.9)	(12.4, 21.8)	(13.1, 19.1)	(13.4, 18.0)	(13.6, 16.8)
2002	15.3	2.10	(12.4, 21.9)	(12.8, 20.4)	(13.3, 18.2)	(13.7, 17.0)	(13.9, 16.7)
2003	14.8	1.97	(10.1, 18.8)	(11.9, 18.0)	(13.2, 16.9)	(13.6, 16.5)	(13.8, 16.0)
2004	14.7	2.02	(10.6, 19.2)	(11.2, 18.2)	(12.3, 17.0)	(13.2, 16.1)	(13.6, 15.9)
2005	14.6	1.49	(11.3, 17.9)	(12.1, 17.4)	(12.9, 16.2)	(13.3, 15.6)	(13.6, 15.4)
2006	14.6	1.66	(11.0, 17.4)	(12.2, 17.2)	(13.3, 16.4)	(13.7, 16.0)	(14.0, 15.6)
2007	15.0	2.25	(11.7, 20.9)	(11.9, 20.5)	(12.5, 17.1)	(13.0, 16.6)	(13.4, 16.4)
2008	14.9	1.93	(10.5, 17.9)	(12.3, 17.6)	(13.0, 17.2)	(13.4, 16.8)	(13.7, 16.3)

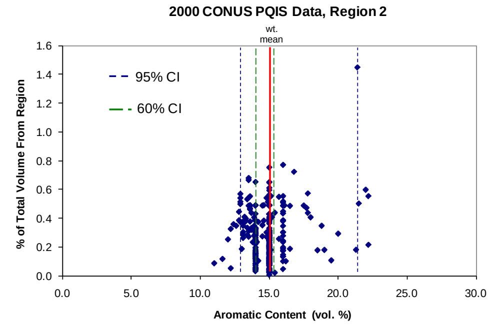
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 2 Based on the Loglogistic Distribution of PQIS Data from 1997-2008.

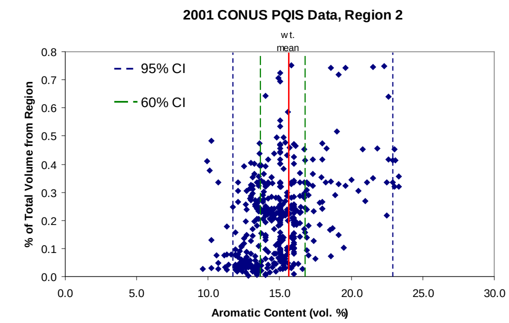
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1997	1.90	(10.6, 18.3)	(11.3, 17.5)	(12.1, 16.7)	(12.6, 16.2)	(13.0, 15.9)	0.955
1998	3.16	(8.4, 21.2)	(9.7, 19.9)	(10.9, 18.6)	(11.7, 17.8)	(12.3, 17.2)	0.917
1999	1.95	(12.0, 19.7)	(12.5, 18.6)	(13.0, 17.6)	(13.4, 17.0)	(13.7, 16.5)	0.914
2000	1.47	(12.8, 18.4)	(13.1, 17.5)	(13.4, 16.7)	(13.6, 16.2)	(13.8, 15.9)	0.957
2001	2.58	(11.6, 21.6)	(12.1, 20.1)	(12.8, 18.6)	(13.2, 17.8)	(13.6, 17.2)	0.981
2002	1.97	(11.8, 19.7)	(12.4, 18.7)	(13.0, 17.7)	(13.4, 17.1)	(13.8, 16.7)	0.969
2003	1.89	(11.0, 18.6)	(11.7, 17.9)	(12.5, 17.1)	(13.0, 16.6)	(13.3, 16.2)	0.965
2004	1.98	(10.7, 18.8)	(11.5, 17.9)	(12.3, 17.1)	(12.8, 16.6)	(13.1, 16.2)	0.982
2005	1.47	(11.8, 17.8)	(12.3, 17.1)	(12.9, 16.4)	(13.2, 16.0)	(13.5, 15.7)	0.989
2006	1.60	(11.4, 17.8)	(12.0, 17.2)	(12.7, 16.5)	(13.1, 16.1)	(13.4, 15.8)	0.902
2007	2.23	(11.7, 20.3)	(12.1, 18.9)	(12.7, 17.6)	(13.0, 16.8)	(13.3, 16.3)	0.992
2008	1.86	(11.1, 18.6)	(11.9, 17.9)	(12.6, 17.1)	(13.1, 16.7)	(13.5, 16.3)	0.960

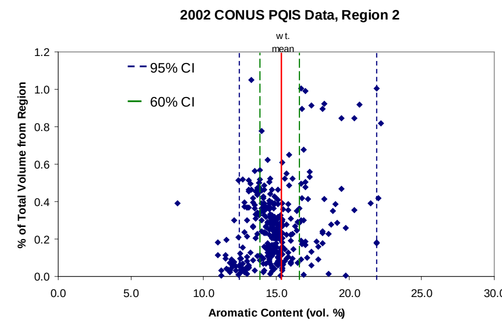


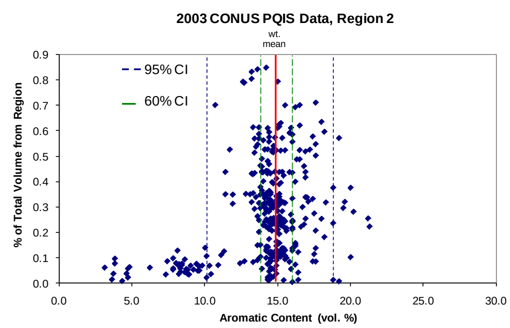


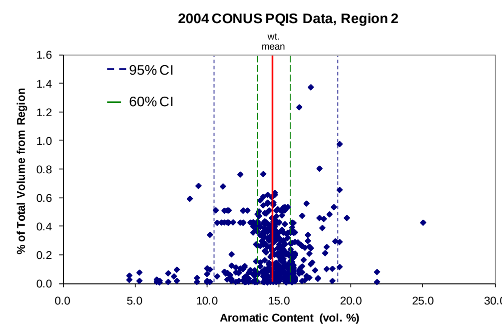

1999 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

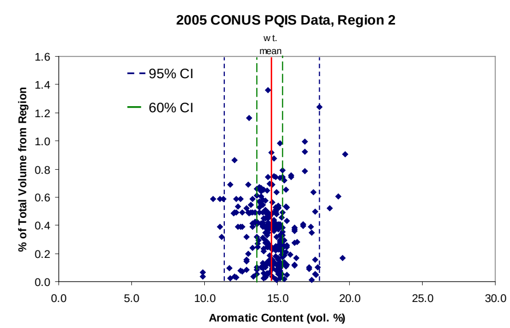

2000 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume From Region
Aromatic Content (vol. %)

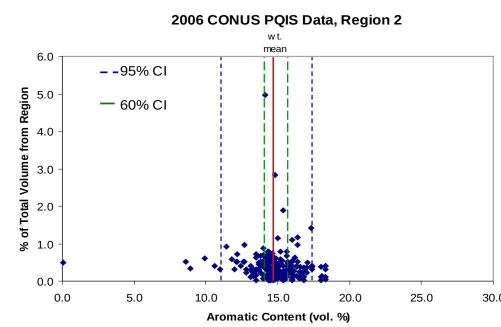

2001 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

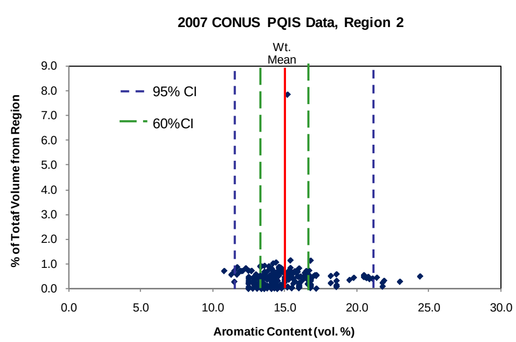

2002 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

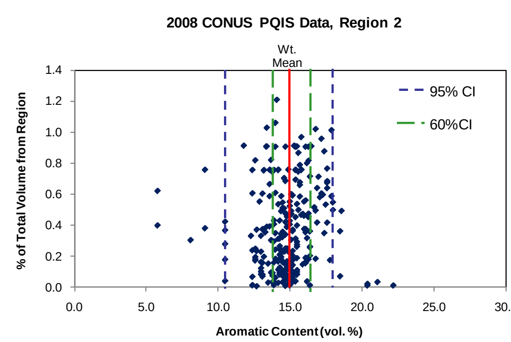

2003 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2004 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2005 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2006 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2007 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

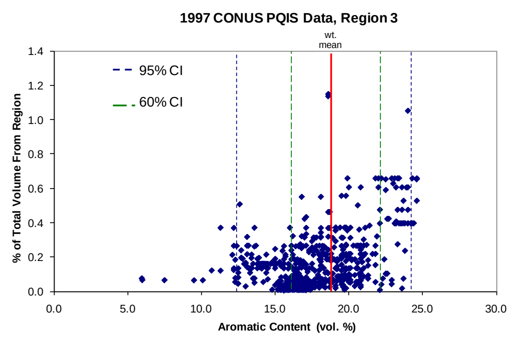

2008 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

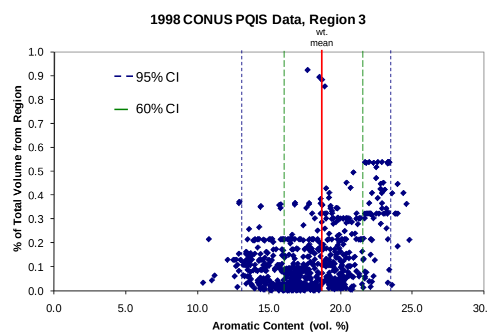
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 3 Based on PQIS Data from 1997-2008.

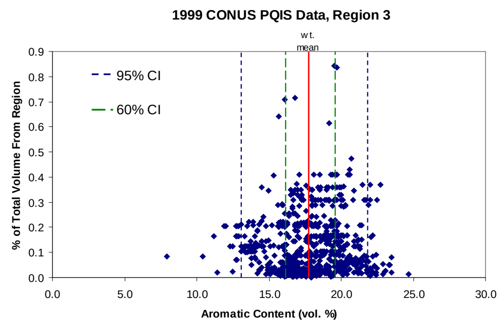
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1997	18.9	3.34	(12.4, 24.3)	(13.1, 24.0)	(14.0, 23.6)	(15.4, 23.1)	(16.1, 22.3)
1998	18.8	2.98	(13.2, 23.8)	(13.6, 23.3)	(14.4, 22.9)	(15.3, 22.3)	(16.1, 21.7)
1999	18.0	2.24	(13.1, 22.0)	(13.8, 21.3)	(14.7, 20.6)	(15.9, 20.1)	(16.3, 19.7)
2000	19.3	2.42	(13.4, 23.1)	(14.0, 22.7)	(15.8, 22.1)	(16.9, 21.7)	(17.5, 21.2)
2001	19.5	2.94	(12.9, 23.9)	(13.6, 23.6)	(15.6, 23.0)	(16.6, 22.6)	(17.3, 22.2)
2002	20.2	3.10	(12.6, 24.3)	(13.9, 24.1)	(15.6, 23.5)	(16.8, 23.1)	(17.4, 22.9)
2003	19.3	3.08	(12.6, 23.7)	(13.2, 23.1)	(15.2, 22.8)	(16.1, 22.4)	(16.7, 21.9)
2004	18.8	2.97	(12.7, 23.7)	(13.4, 23.0)	(14.8, 22.6)	(15.9, 21.9)	(16.4, 21.3)
2005	18.9	2.91	(12.6, 23.2)	(13.2, 22.7)	(15.1, 22.3)	(16.0, 21.8)	(16.7, 21.4)
2006	18.5	3.55	(12.9, 23.5)	(13.1, 22.9)	(13.9, 22.7)	(14.7, 22.3)	(15.3, 21.9)
2007	18.6	3.24	(12.7, 23.4)	(13.1, 23.0)	(14.6, 22.4)	(15.0, 22.0)	(15.6, 21.6)
2008	18.5	3.23	(12.4, 23.9)	(14.1, 23.1)	(14.8, 22.2)	(15.1, 21.7)	(15.4, 21.2)

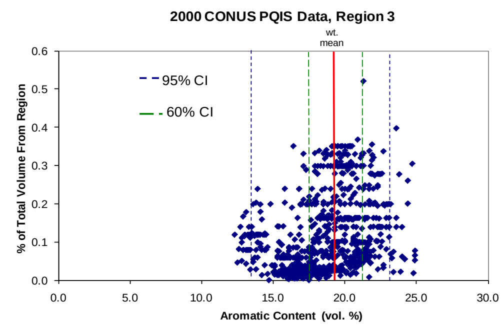
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 3 Based on the Weibull Distribution of PQIS Data from 1997-2008.

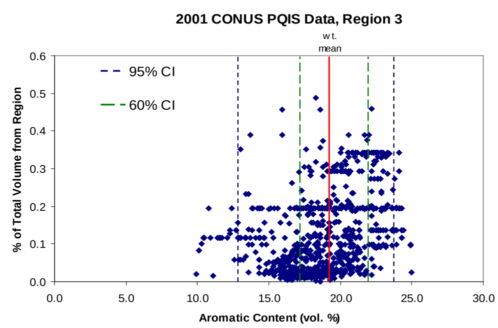
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1997	3.25	(11.9, 24.6)	(13.1, 23.8)	(14.5, 22.9)	(15.5, 22.2)	(16.2, 21.7)	0.990
1998	3.00	(13.0, 24.6)	(13.8, 23.7)	(14.8, 22.6)	(15.5, 21.9)	(16.1, 21.3)	0.994
1999	2.21	(13.0, 21.7)	(14.0, 21.2)	(15.0, 20.6)	(15.7, 20.2)	(16.2, 19.8)	0.996
2000	2.38	(13.8, 23.1)	(14.9, 22.7)	(16.1, 22.1)	(16.9, 21.7)	(17.4, 21.3)	0.987
2001	2.93	(13.0, 24.4)	(14.2, 23.8)	(15.6, 23.0)	(16.4, 22.5)	(17.1, 22.0)	0.995
2002	3.05	(13.2, 25.1)	(14.6, 24.5)	(16.1, 23.7)	(17.0, 23.2)	(17.8, 22.7)	0.984
2003	3.05	(12.2, 24.1)	(13.7, 23.5)	(15.2, 22.8)	(16.2, 22.3)	(16.9, 21.8)	0.991
2004	2.88	(11.9, 23.3)	(13.3, 22.8)	(14.9, 22.1)	(15.8, 21.6)	(16.5, 21.2)	0.991
2005	2.90	(11.9, 23.2)	(13.5, 22.7)	(15.1, 22.1)	(16.0, 21.6)	(16.8, 21.3)	0.997
2006	3.16	(11.7, 24.0)	(12.9, 23.3)	(14.3, 22.4)	(15.2, 21.7)	(15.9, 21.2)	0.986
2007	3.16	(12.6, 24.8)	(13.4, 23.8)	(14.5, 22.7)	(15.2, 21.9)	(15.8, 21.3)	0.994
2008	3.00	(12.7, 24.3)	(13.5, 23.4)	(14.6, 22.4)	(15.3, 21.7)	(15.9, 21.1)	0.990

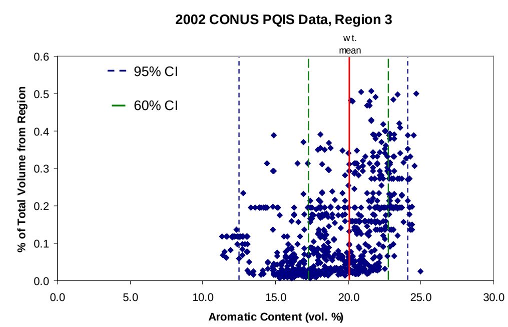


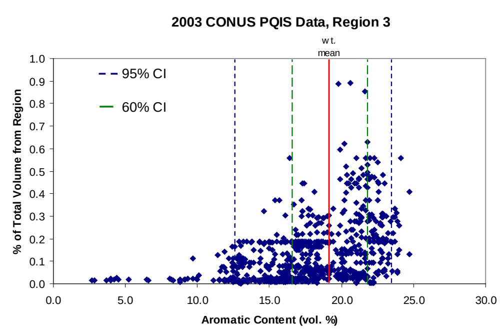


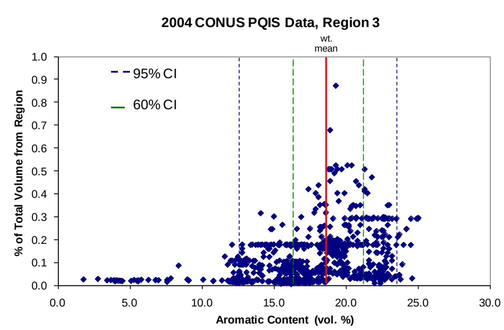

1999 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume From Region
Aromatic Content (vol. %)

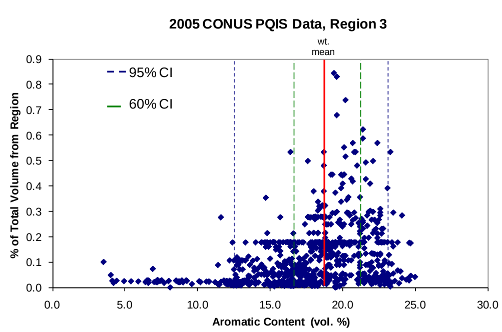

2000 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume From Region
Aromatic Content (vol. %)

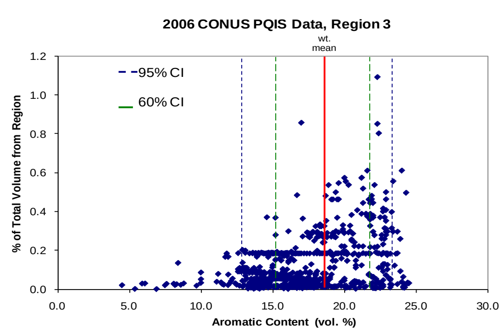

2001 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

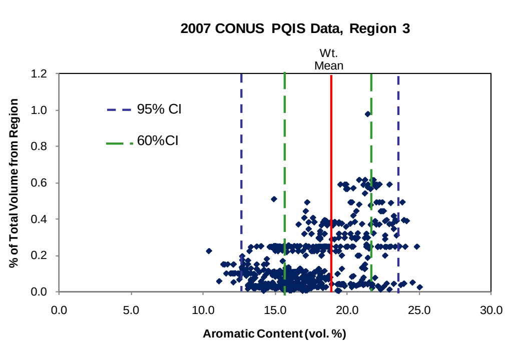

2002 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

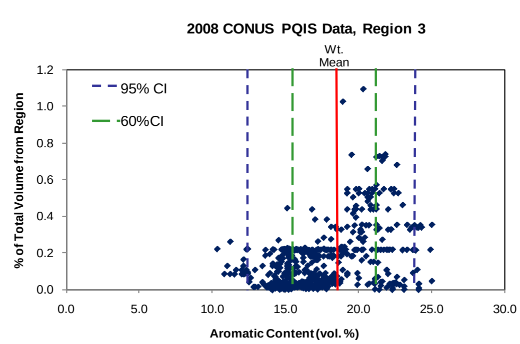

2003 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2004 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2005 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2006 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2007 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

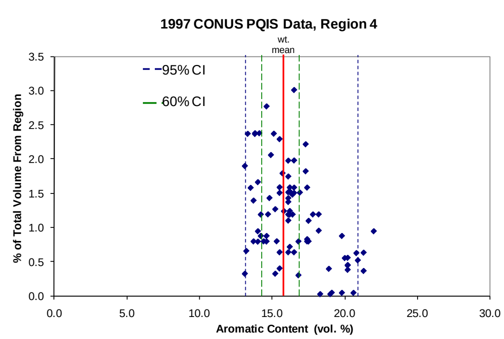

2008 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

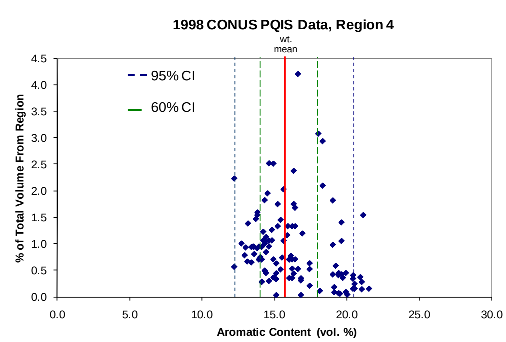
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 4 Based on PQIS Data from 1997-2008.

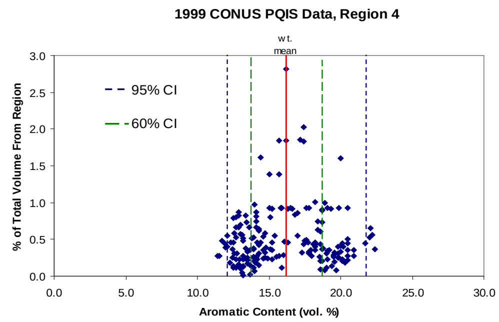
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1997	15.9	1.79	(13.2, 20.8)	(13.3, 20.0)	(13.8, 17.8)	(14.0, 17.4)	(14.2, 16.9)
1998	15.8	2.09	(12.2, 20.5)	(12.9, 19.6)	(13.5, 19.0)	(13.8, 18.3)	(14.1, 18.0)
1999	16.2	2.59	(12.1, 21.7)	(12.5, 20.5)	(12.9, 19.9)	(13.2, 19.1)	(13.7, 18.7)
2000	15.3	3.15	(10.4, 21.8)	(11.3, 21.4)	(12.1, 20.7)	(12.5, 19.6)	(12.8, 18.7)
2001	16.1	3.66	(8.8, 22.7)	(10.6, 22.5)	(12.2, 21.7)	(12.8, 21.3)	(13.4, 20.7)
2002	17.8	3.35	(12.6, 23.7)	(13.0, 22.7)	(14.0, 22.2)	(14.2, 21.8)	(14.8, 21.5)
2003	16.9	2.55	(12.5, 23.4)	(14.4, 21.8)	(14.8, 21.1)	(15.0, 20.1)	(15.1, 19.7)
2004	17.1	2.40	(13.6, 22.5)	(14.1, 21.0)	(14.7, 20.6)	(15.0, 20.1)	(15.4, 19.8)
2005	16.4	3.29	(12.2, 23.1)	(12.4, 22.5)	(13.0, 21.7)	(13.4, 20.8)	(13.4, 20.5)
2006	16.7	3.42	(12.1, 23.1)	(13.0, 22.5)	(13.5, 21.7)	(13.8, 21.4)	(14.0, 20.7)
2007	17.3	2.75	(13.0, 22.5)	(13.2, 21.8)	(13.5, 21.3)	(13.9, 20.7)	(14.0, 20.0)
2008	15.8	3.69	(8.5, 22.3)	(11.1, 21.9)	(12.7, 20.9)	(13.3, 20.5)	(13.5, 20.0)

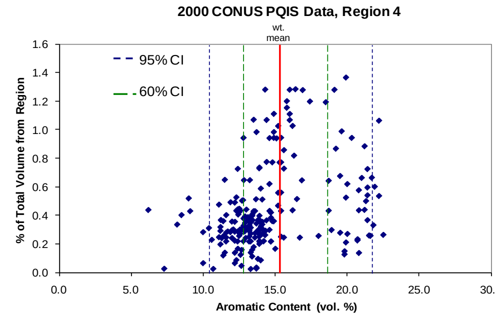
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 4 Based on the Lognormal Distribution of PQIS Data from 1997-2008.

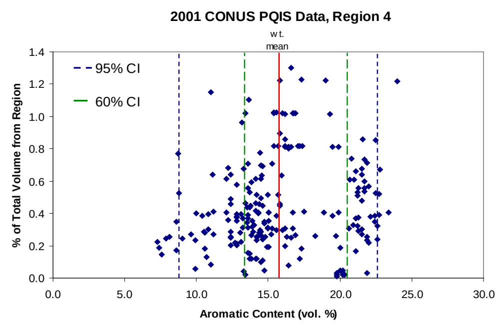
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1997	1.75	(13.2, 20.0)	(13.5, 19.1)	(13.9, 18.2)	(14.2, 17.6)	(14.4, 17.2)	0.984
1998	2.11	(12.6, 20.8)	(13.0, 19.7)	(13.4, 18.6)	(13.7, 17.9)	(14.0, 17.4)	0.992
1999	2.61	(11.9, 22.1)	(12.4, 20.9)	(13.1, 19.6)	(13.6, 18.8)	(13.9, 18.2)	0.995
2000	3.07	(10.0, 22.0)	(10.7, 20.7)	(11.5, 19.3)	(12.2, 18.4)	(12.7, 17.7)	0.978
2001	3.62	(9.7, 23.9)	(10.6, 22.5)	(11.7, 20.9)	(12.4, 19.9)	(13.0, 19.1)	0.986
2002	3.35	(12.2, 25.3)	(12.9, 23.8)	(13.8, 22.2)	(14.4, 21.2)	(15.0, 20.5)	0.976
2003	2.38	(12.9, 22.2)	(13.4, 21.1)	(14.0, 20.0)	(14.5, 19.3)	(14.8, 18.7)	0.961
2004	2.31	(13.4, 22.4)	(13.8, 21.3)	(14.4, 20.1)	(14.8, 19.4)	(15.1, 18.9)	0.977
2005	3.45	(11.9, 25.1)	(12.3, 22.9)	(12.9, 20.8)	(13.3, 19.6)	(13.6, 18.7)	0.980
2006	3.39	(10.1, 23.4)	(11.2, 22.3)	(12.4, 21.1)	(13.2, 20.2)	(13.9, 19.6)	0.960
2007	2.87	(11.7, 22.9)	(12.6, 22.0)	(13.6, 21.0)	(14.3, 20.3)	(14.9, 19.7)	0.971
2008	3.27	(9.7, 22.5)	(10.5, 21.3)	(11.6, 19.9)	(12.3, 19.0)	(12.8, 18.3)	0.962

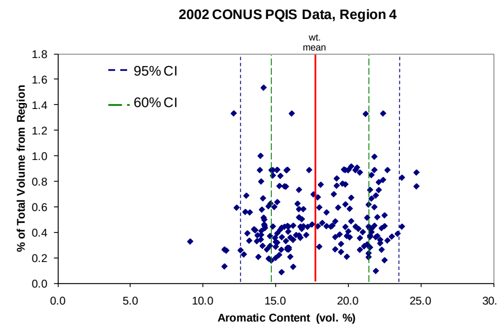


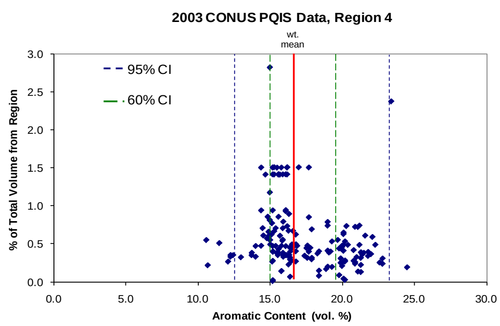


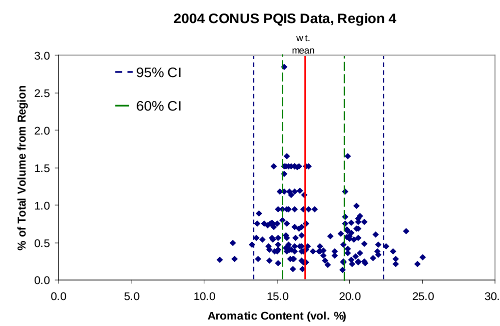

1999 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume From Region
Aromatic Content (vol. %)

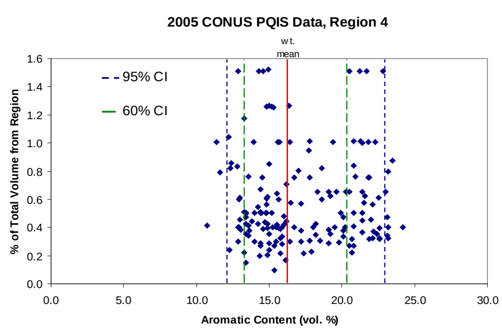

2000 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

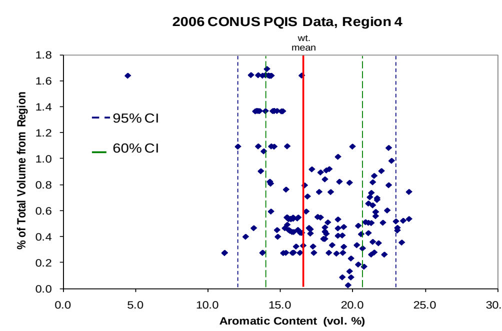

2001 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

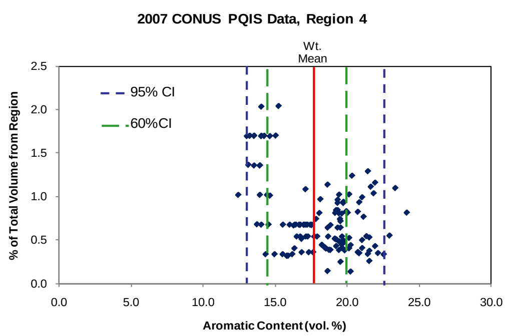

2002 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

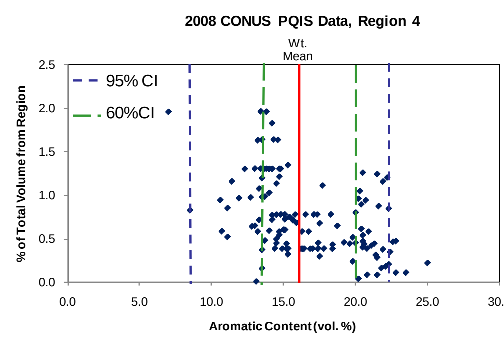

2003 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2004 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2005 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2006 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2007 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

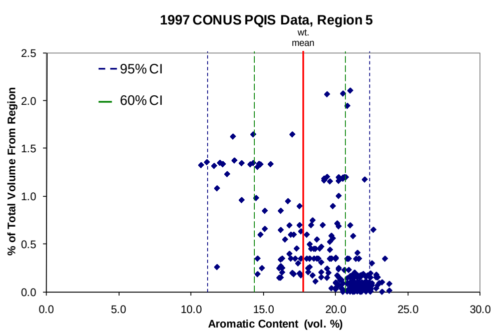

2008 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

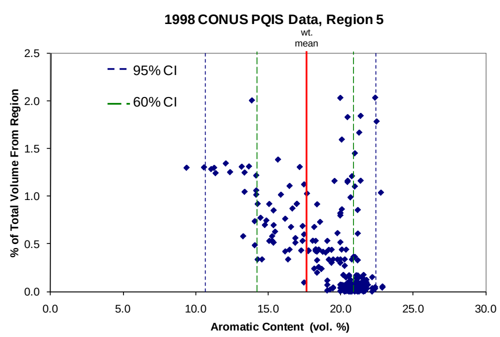
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 5 Based on PQIS Data from 1997-2008.

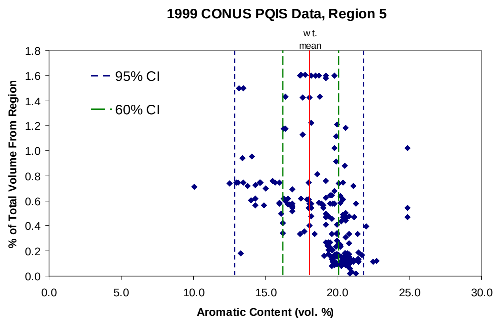
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1997	17.8	3.28	(11.1, 22.4)	(11.8, 22.0)	(12.5, 21.5)	(13.5, 21.0)	(14.3, 20.7)
1998	17.7	3.37	(10.6, 22.5)	(11.3, 22.4)	(13.2, 21.4)	(13.9, 21.2)	(14.2, 20.9)
1999	18.2	2.55	(13.1, 22.0)	(13.4, 21.2)	(14.1, 20.6)	(15.5, 20.4)	(16.3, 20.2)
2000	17.6	2.38	(12.3, 21.6)	(13.3, 21.0)	(13.6, 20.3)	(14.6, 19.5)	(15.2, 19.2)
2001	16.8	3.47	(8.1, 21.0)	(9.8, 20.6)	(11.5, 20.0)	(12.7, 19.7)	(13.5, 19.5)
2002	16.7	3.51	(9.3, 21.3)	(9.8, 20.5)	(10.5, 19.9)	(11.7, 19.6)	(12.4, 19.5)
2003	17.6	3.56	(9.6, 21.6)	(10.6, 21.2)	(11.4, 20.9)	(12.9, 20.6)	(14.3, 20.3)
2004	16.7	2.68	(11.7, 21.4)	(12.9, 20.8)	(13.6, 20.4)	(14.0, 20.0)	(14.2, 19.6)
2005	16.2	2.96	(9.6, 20.8)	(10.1, 20.2)	(11.0, 19.2)	(13.8, 19.1)	(14.3, 18.6)
2006	18.4	1.80	(14.9, 21.2)	(15.6, 21.0)	(16.1, 20.1)	(17.0, 19.9)	(17.3, 19.6)
2007	18.1	1.53	(15.5, 20.3)	(16.0, 19.8)	(16.7, 19.3)	(17.1, 19.2)	(17.5, 18.8)
2008	18.7	2.60	(13.6, 21.7)	(14.2, 21.5)	(15.3, 21.0)	(15.9, 20.6)	(16.9, 20.2)

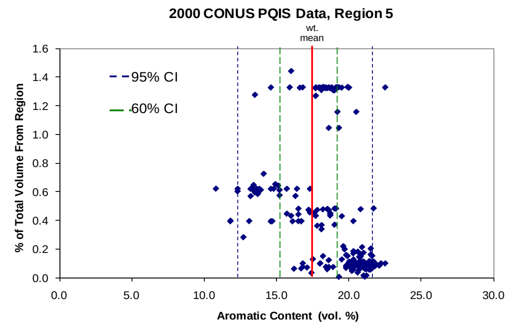
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from Region 5 Based on the Weibull Distribution of PQIS Data from 1997-2008.

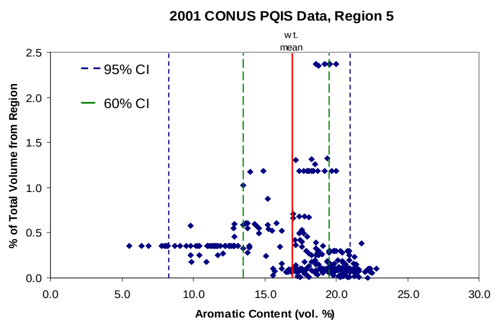
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1997	3.56	(11.5, 25.2)	(12.2, 23.9)	(13.2, 22.5)	(13.9, 21.5)	(14.6, 20.8)	0.974
1998	3.46	(10.9, 24.3)	(11.9, 23.3)	(13.1, 22.2)	(14.0, 21.3)	(14.7, 20.7)	0.983
1999	2.51	(12.7, 22.5)	(13.7, 21.9)	(14.8, 21.2)	(15.6, 20.7)	(16.1, 20.3)	0.985
2000	2.36	(12.5, 21.7)	(13.4, 21.2)	(14.4, 20.5)	(15.1, 20.0)	(15.6, 19.6)	0.978
2001	3.39	(8.6, 21.8)	(10.4, 21.0)	(12.3, 20.5)	(13.4, 20.0)	(14.3, 19.6)	0.976
2002	3.33	(8.7, 21.6)	(10.5, 21.0)	(12.3, 20.4)	(13.4, 19.8)	(14.3, 19.4)	0.949
2003	3.47	(9.7, 23.2)	(11.2, 22.5)	(12.9, 21.6)	(14.0, 21.0)	(14.8, 20.5)	0.969
2004	2.60	(11.8, 21.4)	(12.5, 20.7)	(13.4, 19.9)	(14.0, 19.3)	(14.5, 18.8)	0.985
2005	2.91	(9.2, 20.5)	(10.8, 20.1)	(12.4, 19.4)	(13.3, 19.0)	(14.1, 18.6)	0.984
2006	1.56	(15.1, 21.1)	(15.7, 20.8)	(16.3, 20.3)	(16.8, 20.0)	(17.1, 19.8)	0.995
2007	1.09	(15.6, 19.9)	(16.1, 19.7)	(16.7, 19.4)	(17.0, 19.2)	(17.3, 19.1)	0.985
2008	2.26	(13.3, 22.0)	(14.5, 21.7)	(15.8, 21.2)	(16.5, 20.9)	(17.1, 20.6)	0.984

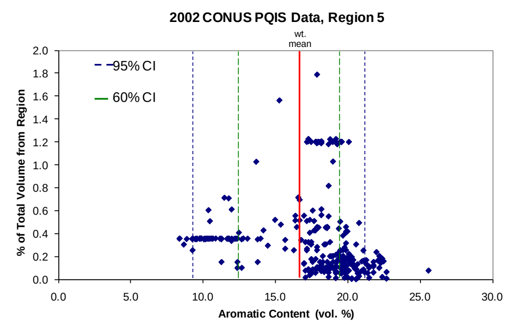


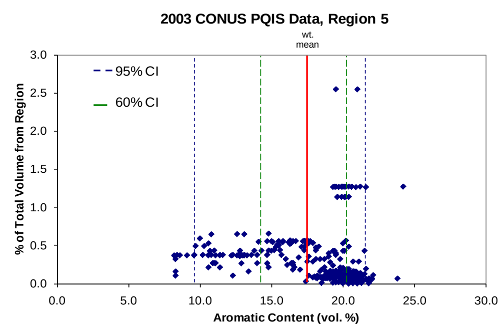


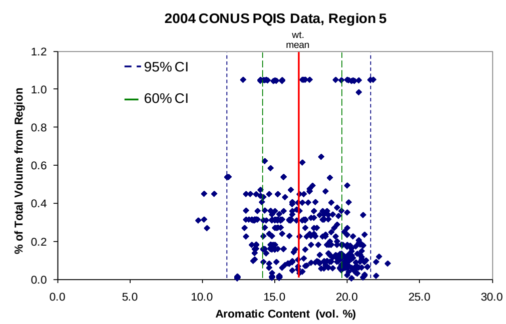

1999 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume From Region
Aromatic Content (vol. %)

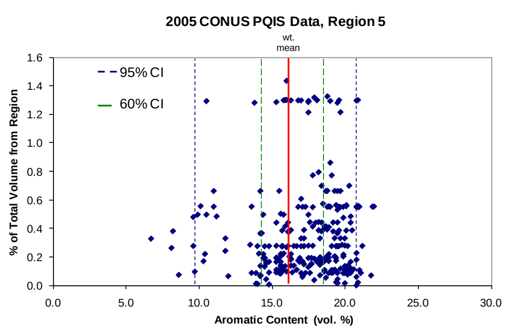

2000 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume From Region
Aromatic Content (vol. %)

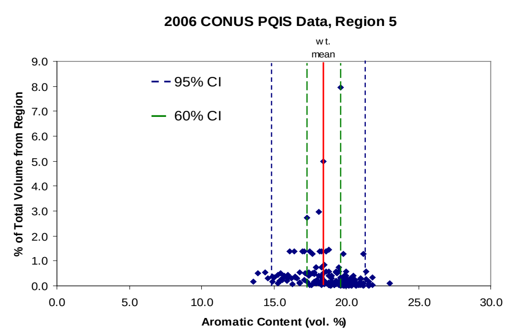

2001 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

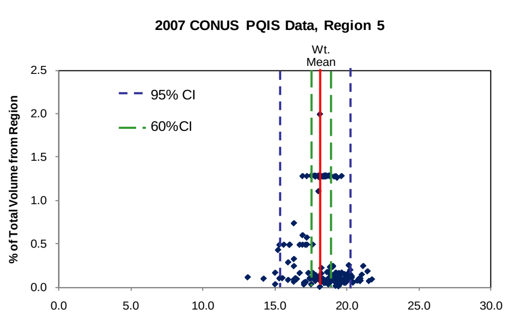

2002 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)

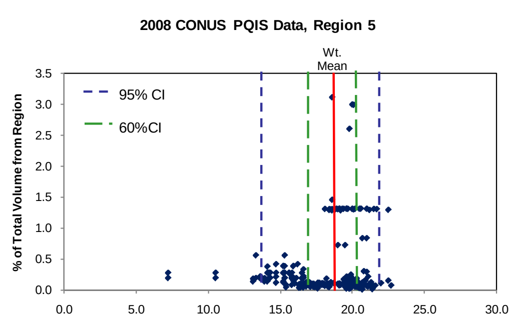

2003 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2004 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2005 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2006 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Aromatic Content (vol. %)


2007 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

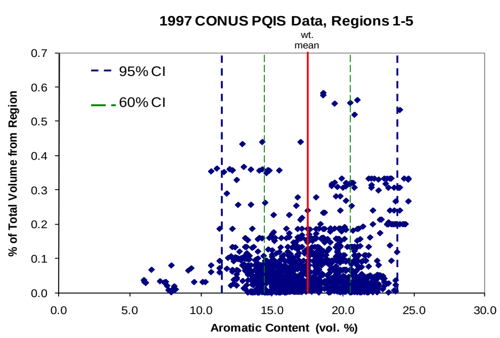

2008 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Aromatic Content (vol. %)

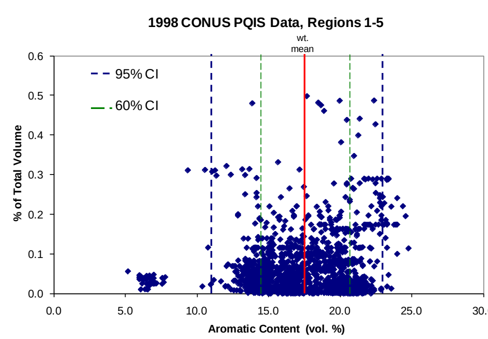
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from CONUS Based on PQIS Data from 1997-2008.

Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1997	17.7	3.15	(11.8, 24.0)	(12.4, 23.6)	(13.4, 22.5)	(14.0, 21.5)	(14.6, 20.8)
1998	17.8	3.17	(11.3, 23.3)	(13.2, 22.9)	(13.9, 22.1)	(14.3, 21.4)	(14.8, 20.8)
1999	17.5	2.61	(12.9, 21.7)	(13.5, 21.1)	(14.0, 20.5)	(14.5, 20.1)	(15.0, 19.7)
2000	18.0	2.11	(12.9, 22.9)	(13.4, 22.2)	(13.9, 21.5)	(14.6, 21.0)	(15.0, 20.4)
2001	18.0	3.48	(10.8, 23.6)	(12.3, 23.2)	(13.4, 22.6)	(14.0, 21.8)	(14.9, 21.1)
2002	18.7	3.49	(10.7, 24.2)	(12.1, 23.7)	(13.7, 23.0)	(14.5, 22.7)	(15.1, 22.1)
2003	18.2	3.84	(11.0, 23.5)	(12.6, 22.9)	(13.8, 22.3)	(14.5, 21.8)	(15.1, 21.4)
2004	17.7	3.55	(11.9, 23.1)	(12.8, 22.6)	(13.9, 21.8)	(14.3, 20.9)	(14.8, 20.3)
2005	17.7	3.44	(10.5, 23.0)	(12.3, 22.5)	(13.6, 21.8)	(14.4, 21.2)	(14.8, 20.6)
2006	17.9	3.24	(12.7, 23.3)	(13.1, 22.9)	(14.0, 22.3)	(14.4, 21.8)	(14.8, 21.2)
2007	18.0	2.99	(12.1, 23.2)	(13.1, 22.7)	(14.1, 22.0)	(14.8, 21.4)	(15.2, 21.0)
2008	18.1	3.19	(12.3, 23.5)	(13.4, 22.5)	(14.3, 21.8)	(14.8, 21.2)	(15.2, 20.8)

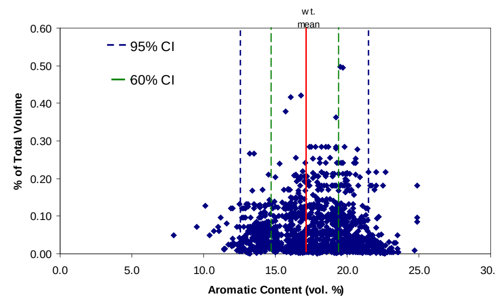
Statistics and Confidence Intervals for the Aromatic Content (vol. %) of JP-8 Fuel from CONUS Based on the Weibull Distribution of PQIS Data from 1997-2008.

Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1997	3.28	(10.9, 23.7)	(12.0, 22.8)	(13.4, 21.8)	(14.3, 21.1)	(15.0, 20.6)	0.989
1998	3.24	(10.6, 23.2)	(11.9, 22.5)	(13.4, 21.7)	(14.4, 21.0)	(15.2, 20.5)	0.987
1999	2.43	(12.4, 22.0)	(13.2, 21.4)	(14.2, 20.6)	(14.9, 20.1)	(15.5, 19.7)	0.992
2000	2.74	(12.2, 22.9)	(13.1, 22.2)	(14.3, 21.4)	(15.1, 20.8)	(15.7, 20.4)	0.985
2001	3.47	(10.5, 23.9)	(11.9, 23.1)	(13.5, 22.2)	(14.5, 21.6)	(15.3, 21.0)	0.997
2002	3.72	(10.3, 24.5)	(12.0, 23.8)	(13.9, 22.9)	(15.0, 22.3)	(15.9, 21.8)	0.993
2003	3.38	(10.5, 23.8)	(12.0, 23.1)	(13.7, 22.3)	(14.8, 21.6)	(15.6, 21.1)	0.994
2004	3.02	(10.9, 22.7)	(12.2, 22.1)	(13.6, 21.3)	(14.6, 20.7)	(15.3, 20.3)	0.986
2005	3.20	(10.5, 23.1)	(11.9, 22.4)	(13.4, 21.6)	(14.4, 21.0)	(15.2, 20.5)	0.998
2006	3.04	(11.0, 22.9)	(12.4, 22.3)	(13.9, 21.5)	(14.8, 21.0)	(15.6, 20.5)	0.976
2007	2.99	(12.4, 23.6)	(13.2, 22.8)	(14.2, 21.8)	(15.0, 21.1)	(15.5, 20.5)	0.997
2008	2.96	(11.6, 23.2)	(12.8, 22.5)	(14.1, 21.7)	(15.0, 21.1)	(15.7, 20.6)	0.989

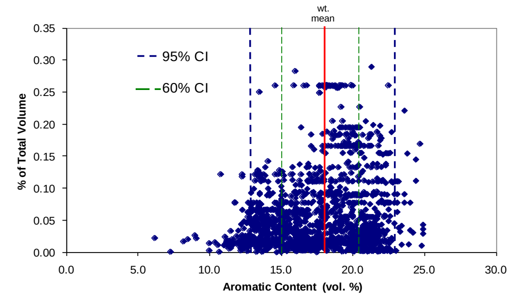




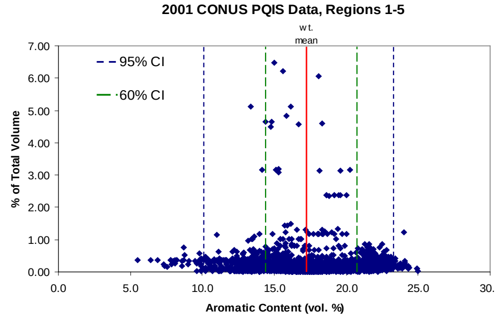
1999 CONUS PQIS Data, Regions 1-5



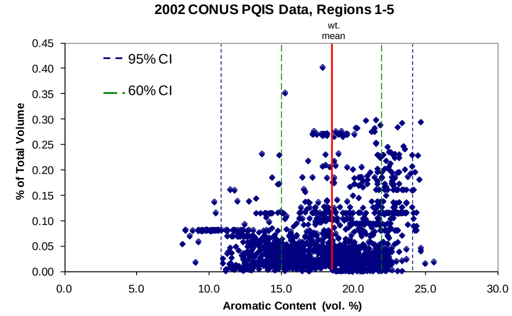
2000 CONUS PQIS Data, Region 1-5



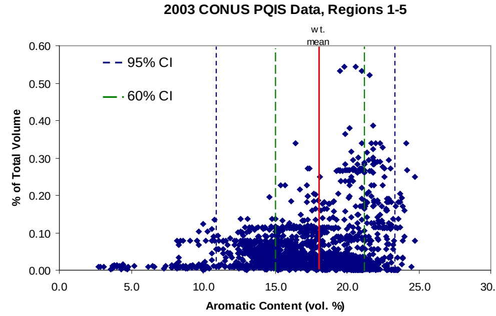
2001 CONUS PQIS Data, Regions 1-5



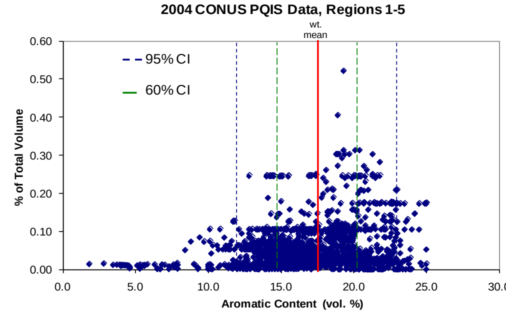
2002 CONUS PQIS Data, Regions 1-5



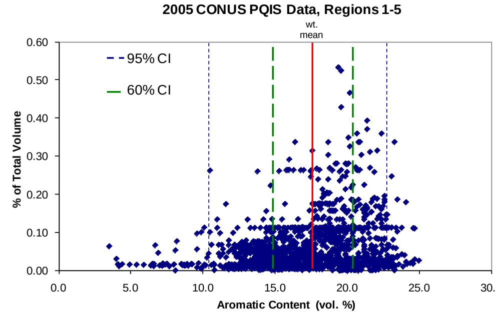
2003 CONUS PQIS Data, Regions 1-5



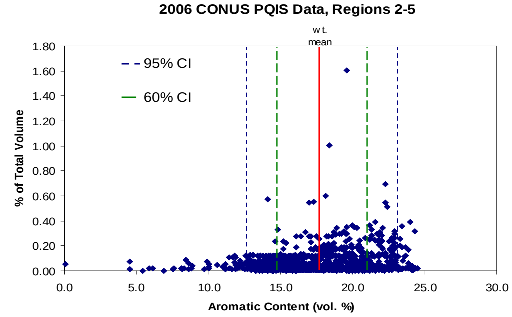
2004 CONUS PQIS Data, Regions 1-5



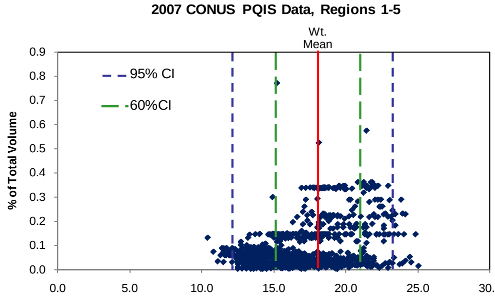
2005 CONUS PQIS Data, Regions 1-5



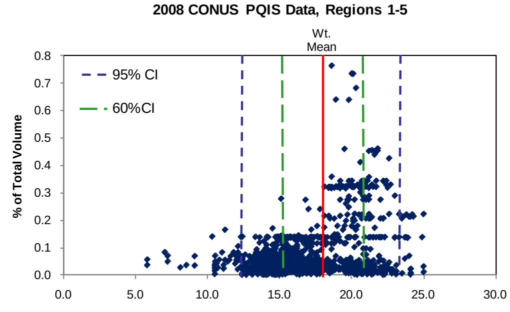
2006 CONUS PQIS Data, Regions 2-5



2007 CONUS PQIS Data, Regions 1-5



2008 CONUS PQIS Data, Regions 1-5



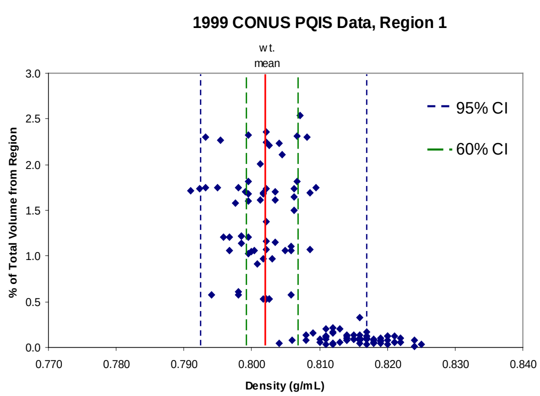
7.2 Density

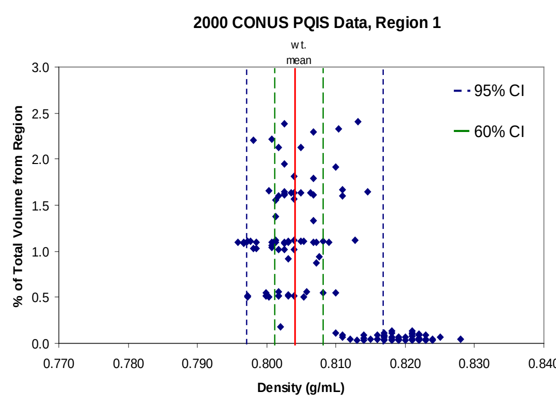
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 1 Based on PQIS Data from 1999-2008.

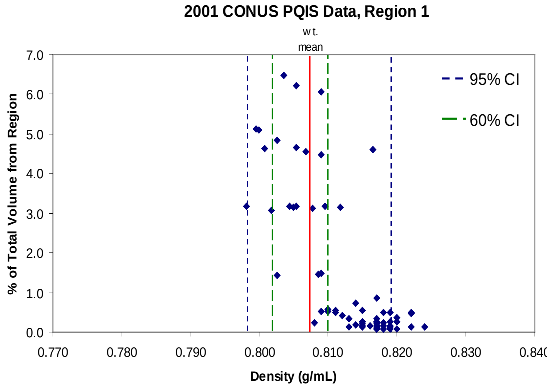
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	0.802	0.0106	(.792, .817)	(.793, .812)	(.795, .809)	(.797, .807)	(.799, .807)
2000	0.804	0.0103	(.797, .817)	(.797, .813)	(.798, .811)	(.800, .810)	(.801, .808)
2001	0.807	0.0090	(.798, .819)	(.799, .817)	(.800, .817)	(.801, .812)	(.802, .810)
2002	0.816	0.0047	(.810, .824)	(.810, .823)	(.811, .820)	(.813, .819)	(.813, .818)
2003	0.817	0.0070	(.804, .826)	(.805, .825)	(.812, .823)	(.812, .823)	(.813, .823)
2004	0.817	0.0107	(.791, .830)	(.795, .829)	(.804, .827)	(.811, .826)	(.811, .824)
2005	0.795	0.0229	(.793, .821)	(.793, .811)	(.793, .795)	(.793, .795)	(.793, .795)
2007	0.794	0.0029	(.792, .809)	(.792, .796)	(.792, .796)	(.792, .796)	(.792, .795)
2008	0.794	0.0004	(.793, .794)	(.793, .794)	(.793, .794)	(.793, .794)	(.793, .794)

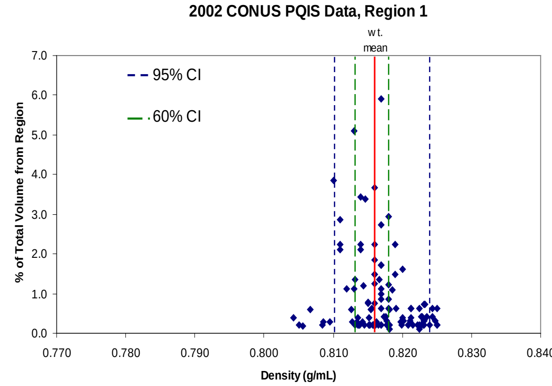
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 1 Based on the Lognormal Distribution of PQIS Data from 1999-2008.

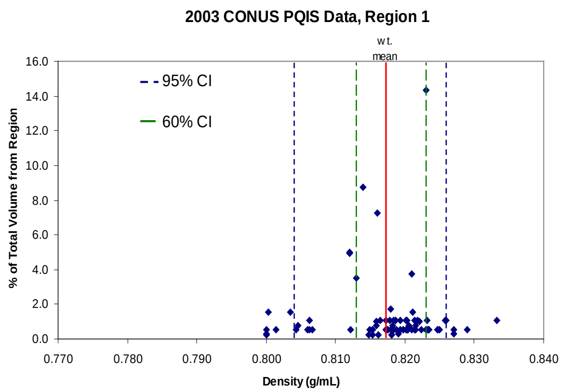
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.0055	(.793, .814)	(.794, .813)	(.796, .810)	(.797, .808)	(.798, .807)	0.991
2000	0.0049	(.797, .816)	(.798, .813)	(.799, .811)	(.799, .809)	(.800, .808)	0.992
2001	0.0056	(.798, .820)	(.799, .817)	(.800, .814)	(.801, .812)	(.802, .811)	0.988
2002	0.0035	(.809, .823)	(.810, .824)	(.811, .821)	(.812, .820)	(.813, .819)	0.988
2003	0.0059	(.803, .826)	(.805, .824)	(.807, .822)	(.808, .821)	(.810, .820)	0.970
2004	0.0089	(.800, .835)	(.803, .832)	(.806, .829)	(.808, .827)	(.810, .825)	0.956
2005	0.0019	(.791, .798)	(.791, .798)	(.792, .797)	(.792, .796)	(.793, .796)	0.609
2007	0.0020	(.791, .799)	(.791, .798)	(.792, .797)	(.792, .796)	(.793, .796)	0.852
2008	-	-	-	-	-	-	-

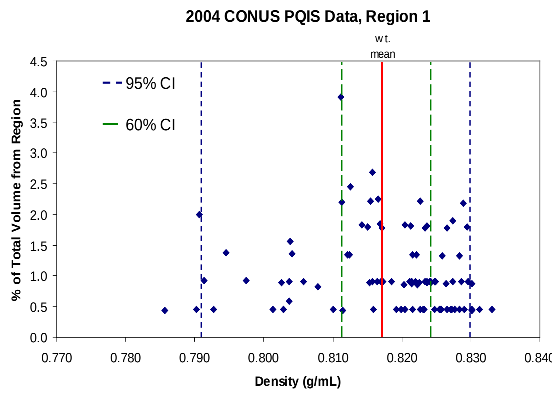


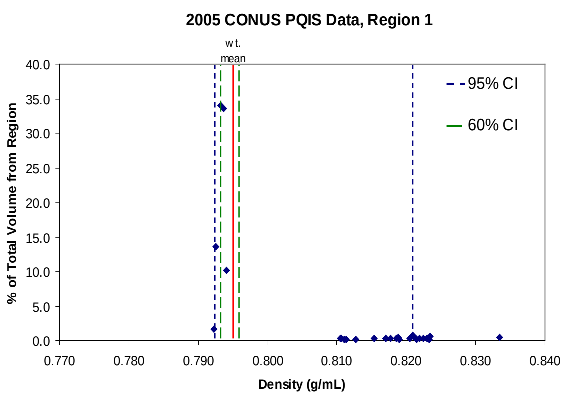


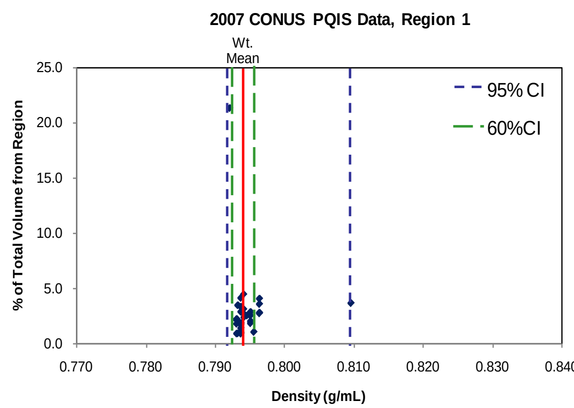

2001 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)

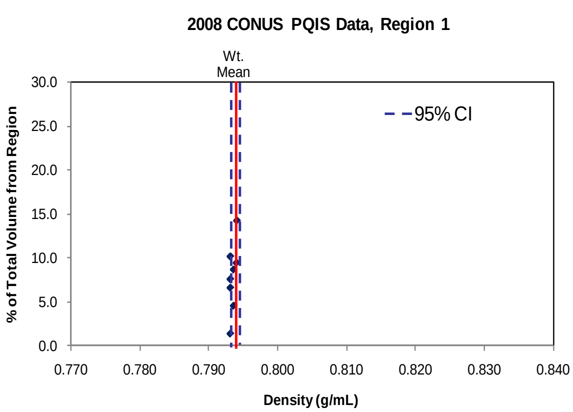

2002 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2003 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2004 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2005 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2007 CONUS PQIS Data, Region 1
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)

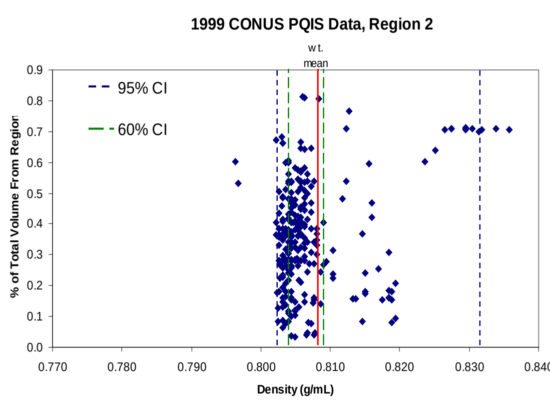

2008 CONUS PQIS Data, Region 1
Wt. Mean
95% CI
% of Total Volume from Region
Density (g/mL)

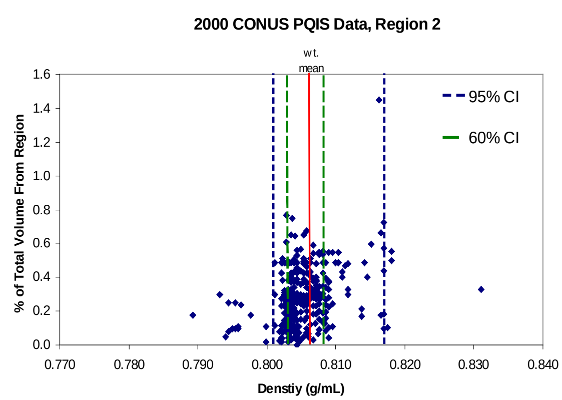
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 2 Based on PQIS Data from 1999-2008.

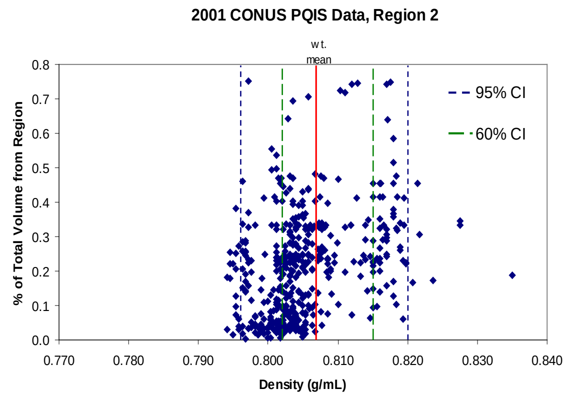
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	0.808	0.0063	(.802, .831)	(.803, .829)	(.803, .818)	(.803, .813)	(.804, .808)
2000	0.806	0.0040	(.801, .817)	(.802, .816)	(.803, .811)	(.803, .809)	(.803, .808)
2001	0.807	0.0067	(.796, .820)	(.797, .819)	(.799, .817)	(.801, .816)	(.802, .815)
2002	0.807	0.0066	(.795, .819)	(.796, .818)	(.801, .816)	(.803, .815)	(.804, .812)
2003	0.807	0.0064	(.795, .819)	(.796, .816)	(.799, .812)	(.803, .811)	(.804, .810)
2004	0.808	0.0085	(.799, .824)	(.799, .820)	(.801, .814)	(.804, .812)	(.805, .810)
2005	0.806	0.0055	(.800, .812)	(.801, .811)	(.801, .809)	(.802, .808)	(.804, .808)
2006	0.806	0.0042	(.800, .813)	(.801, .811)	(.802, .809)	(.803, .809)	(.804, .808)
2007	0.804	0.0022	(.801, .813)	(.801, .810)	(.802, .806)	(.802, .806)	(.802, .806)
2008	0.805	0.0035	(.799, .811)	(.799, .811)	(.800, .809)	(.801, .808)	(.802, .807)

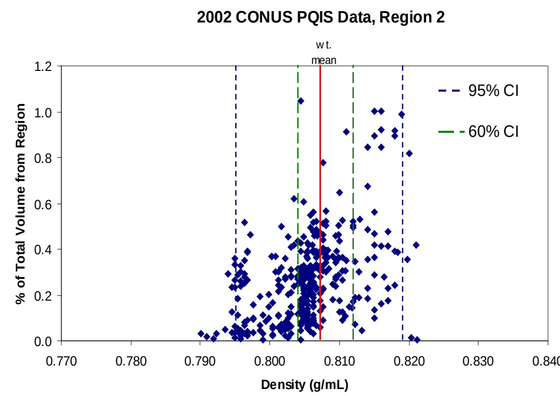
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 2 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

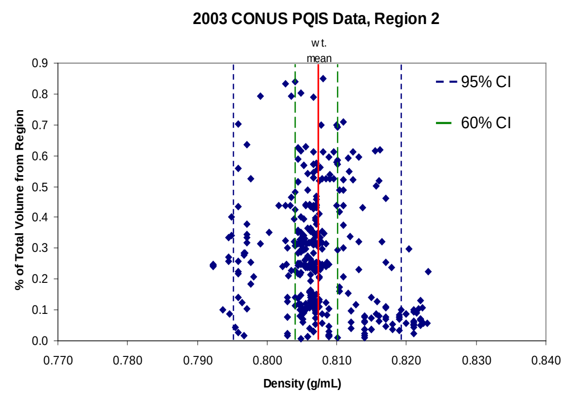
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.0055	(.799, .820)	(.800, .817)	(.802, .814)	(.803, .812)	(.803, .811)	0.889
2000	0.0039	(.799, .814)	(.800, .812)	(.801, .810)	(.802, .809)	(.803, .808)	0.950
2001	0.0072	(.796, .825)	(.797, .820)	(.799, .816)	(.800, .813)	(.801, .812)	0.978
2002	0.0063	(.797. .821)	(.799, .818)	(.800, .815)	(.802, .813)	(.803, .812)	0.975
2003	0.0051	(.796, .817)	(.798, .815)	(.800, .813)	(.802, .811)	(.803, .810)	0.974
2004	0.0053	(.799, .820)	(.801, .817)	(.802, .814)	(.803, .813)	(.804, .812)	0.974
2005	0.0034	(.800, .813)	(.801, .811)	(.802, .810)	(.803, .809)	(.803, .808)	0.971
2006	0.0035	(.800, .814)	(.801,.812)	(.802, .810)	(.803, .809)	(.803, .809)	0.958
2007	0.0023	(.800, .809)	(.801, .808)	(.801, .807)	(.802, .806)	(.802, .806)	0.962
2008	0.0034	(.799, .812)	(.800, .810)	(.801, .809)	(.801, .808)	(.802, .807)	0.978

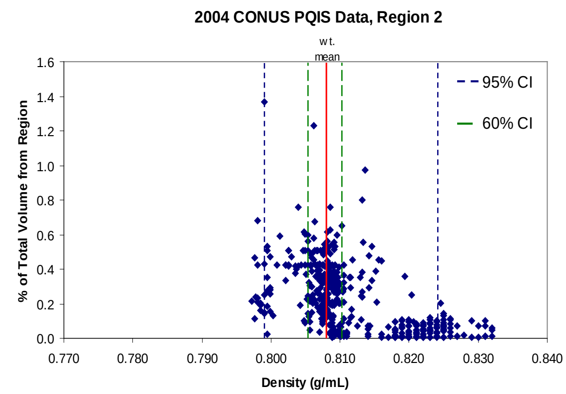


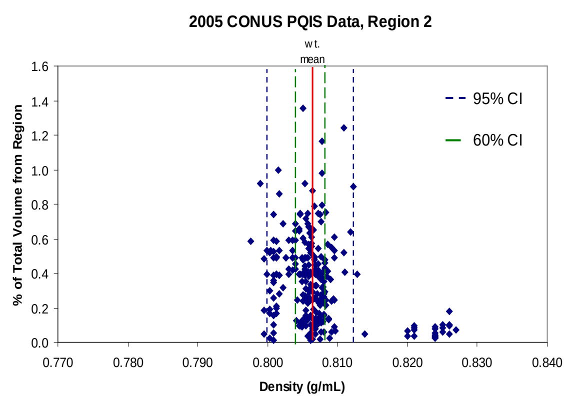


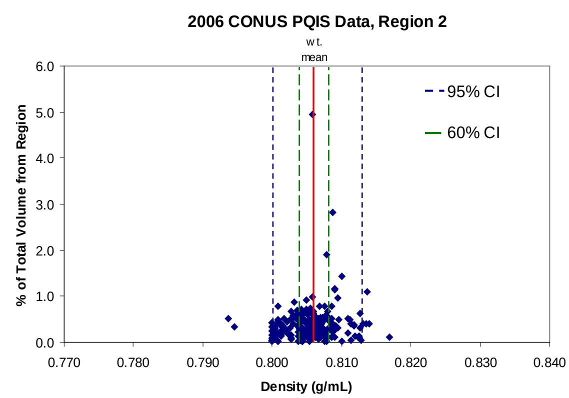

2001 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840

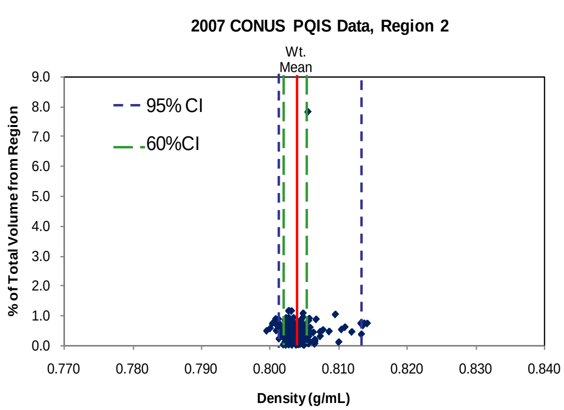

2002 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840

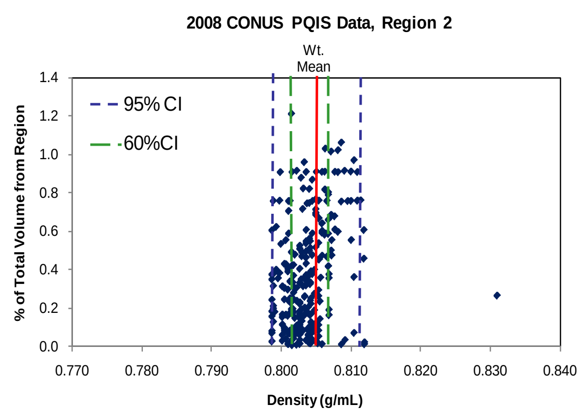

2003 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2004 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2005 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2006 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2007 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840

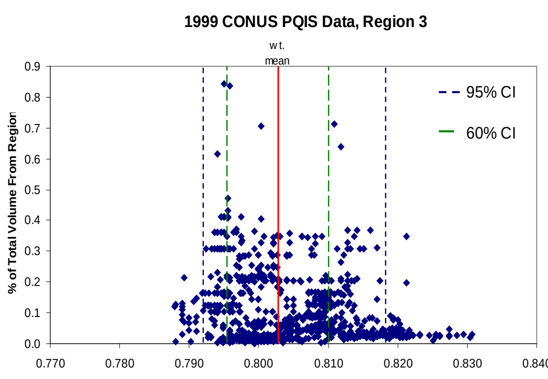

2008 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840

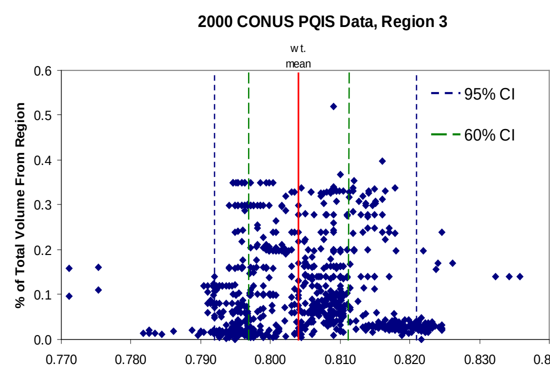
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 3 Based on PQIS Data from 1999-2008.

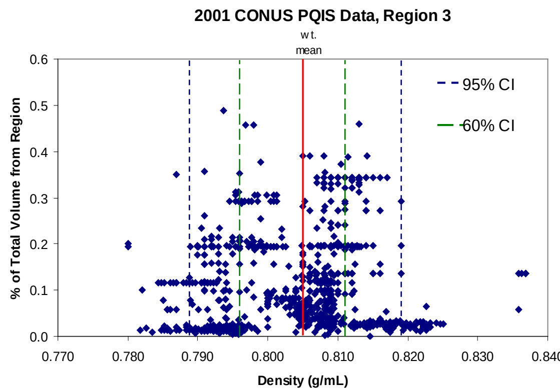
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	0.803	0.0081	(.792, .818)	(.794, .815)	(.794, .813)	(.795, .811)	(.795, .810)
2000	0.804	0.0097	(.792, .821)	(.794, .817)	(.795, .815)	(.796, .812)	(.797, .811)
2001	0.805	0.0096	(.789, .819)	(.791, .815)	(.792, .813)	(.795, .812)	(.796, .811)
2002	0.807	0.0096	(.787, .818)	(.791, .817)	(.794, .815)	(.799, .814)	(.803, .813)
2003	0.806	0.0104	(.789, .815)	(.791, .815)	(.794, .814)	(.798, .813)	(.801, .812)
2004	0.801	0.0099	(.789, .816)	(.790, .815)	(.791, .813)	(.797, .811)	(.792, .810)
2005	0.803	0.0102	(.789, .815)	(.790, .814)	(.792, .812)	(.793, .811)	(.794, .810)
2006	0.805	0.0093	(.790, .816)	(.791, .815)	(.793, .813)	(.796, .812)	(.797, .810)
2007	0.804	0.0090	(.789, .814)	(.790, .813)	(.792, .811)	(.794, .810)	(.797, .809)
2008	0.803	0.0076	(.790, .811)	(.792, .811)	(.793, .810)	(.794, .809)	(.796, .808)

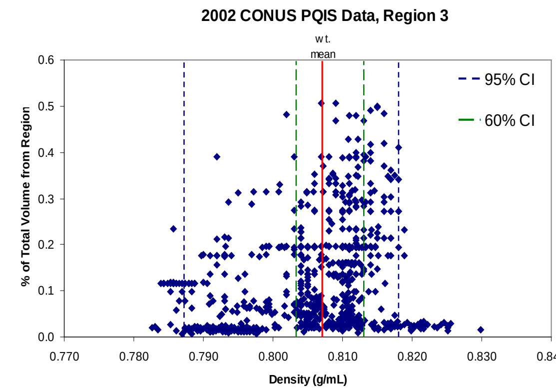
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 3 Based on the Lognormal Distribution of PQIS Data from 1999-2008.

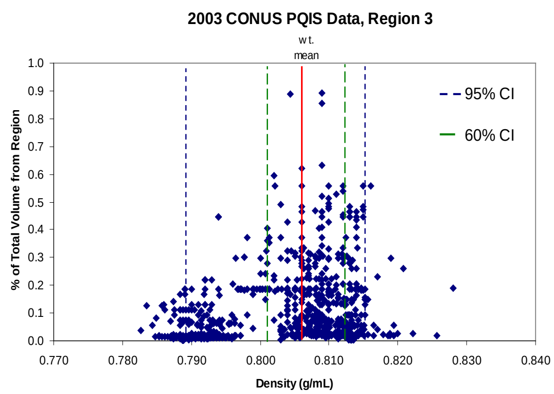
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.0077	(.791, .821)	(.792, .817)	(.794, .813)	(.795, .810)	(.796, .808)	0.984
2000	0.0082	(.788, .820)	(.791, .818)	(.794, .815)	(.796, .813)	(.797, .811)	0.981
2001	0.0089	(.788, .824)	(.791, .821)	(.793, .817)	(.795, .814)	(.797, .812)	0.966
2002	0.0073	(.793, .822)	(.796, .820)	(.798, .817)	(.800, .815)	(.802, .814)	0.948
2003	0.0071	(.792, .820)	(.795, .818)	(.797, .815)	(.799, .814)	(.800, .812)	0.958
2004	0.0085	(.786, .822)	(.788, .818)	(.791, .813)	(.792, .811)	(.794, .809)	0.960
2005	0.0075	(.789, .818)	(.791, .816)	(.794, .813)	(.796, .811)	(.797, .810)	0.971
2006	0.0071	(.791, .818)	(.793, .816)	(.796, .814)	(.797, .812)	(.799, .811)	0.974
2007	0.0069	(.791, .818)	(.793, .816)	(.795, .813)	(.797, .811)	(.798, .810)	0.951
2008	0.0062	(.790, .815)	(.792, .813)	(.795, .811)	(.796, .809)	(.797, .808)	0.966

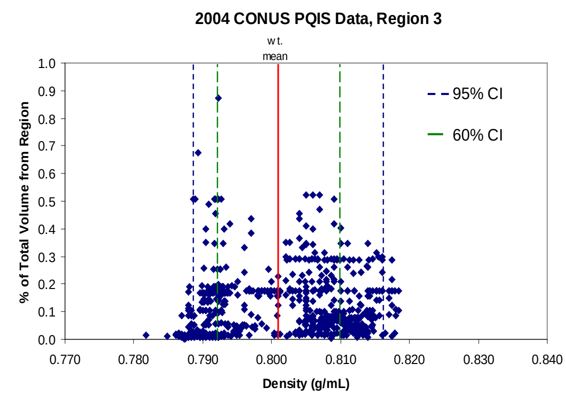


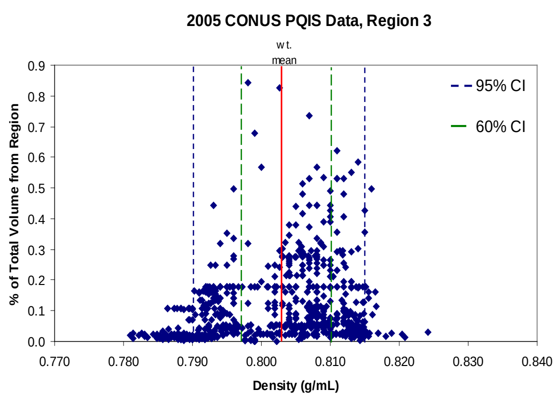


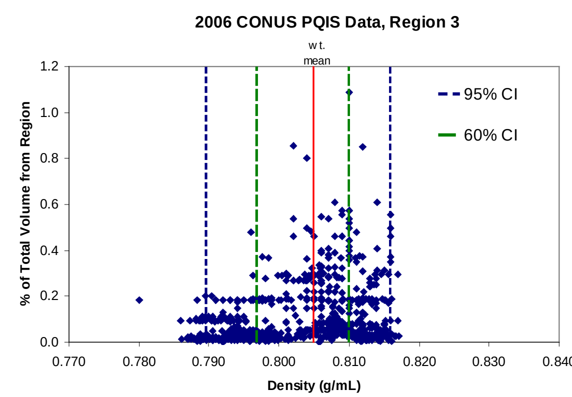

2001 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)

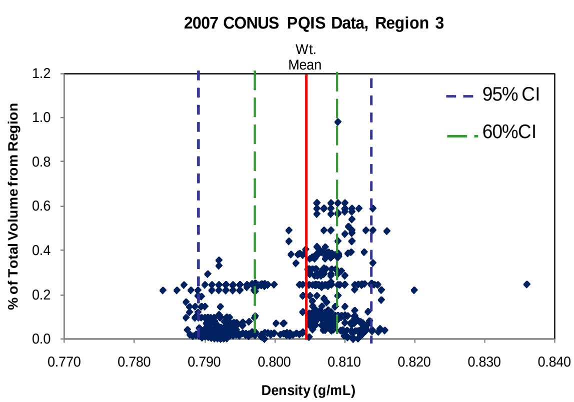

2002 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)

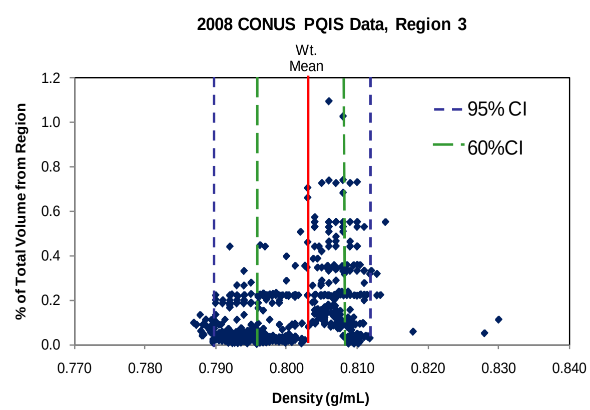

2003 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2004 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2005 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2006 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2007 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)

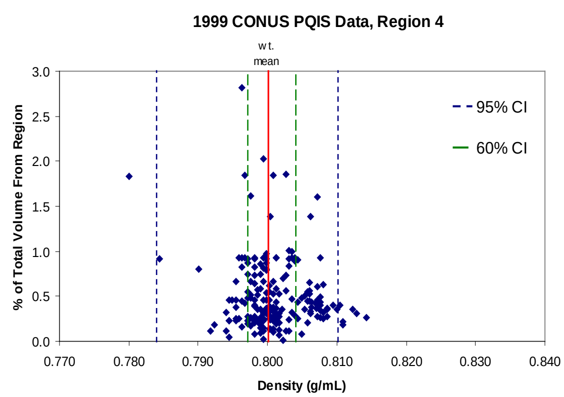

2008 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)

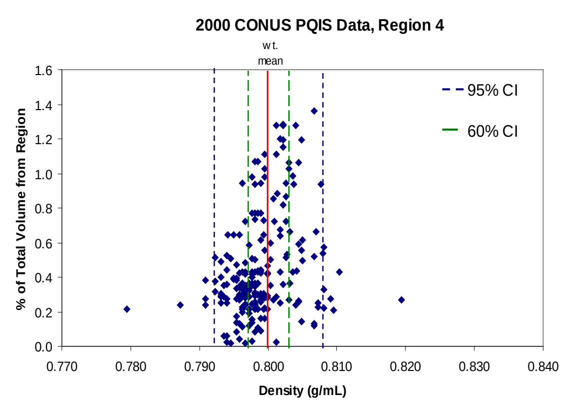
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 4 Based on PQIS Data from 1999-2008.

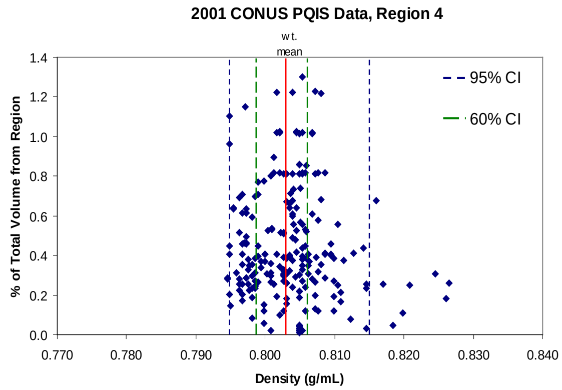
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	0.800	0.0047	(.784, .810)	(.795, .808)	(.796, .807)	(.797, .806)	(.797, .804)
2000	0.800	0.0044	(.792, .808)	(.794, .807)	(.795, .805)	(.796, .804)	(.797, .803)
2001	0.803	0.0085	(.795, .815)	(.796, .810)	(.797, .808)	(.797, .807)	(.799, .806)
2002	0.806	0.0094	(.794, .828)	(.795, .826)	(.796, .817)	(.797, .815)	(.798, .814)
2003	0.803	0.0064	(.797, .818)	(.797, .816)	(.798, .809)	(.799, .807)	(.799, .805)
2004	0.803	0.0064	(.797, .817)	(.798, .819)	(.799, .809)	(.800, .805)	(.800, .805)
2005	0.802	0.0079	(.794, .818)	(.795, .817)	(.796, .811)	(.796, .809)	(.797, .807)
2006	0.803	0.0093	(.794, .823)	(.795, .820)	(.795, .817)	(.795, .816)	(.796, .812)
2007	0.806	0.0112	(.791, .826)	(.792, .826)	(.794, .825)	(.794, .823)	(.796, .821)
2008	0.804	0.0074	(.796, .819)	(.796, .817)	(.797, .813)	(.798, .811)	(.798, .809)

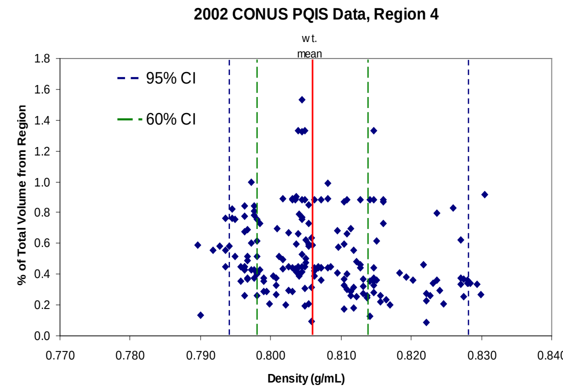
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 4 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

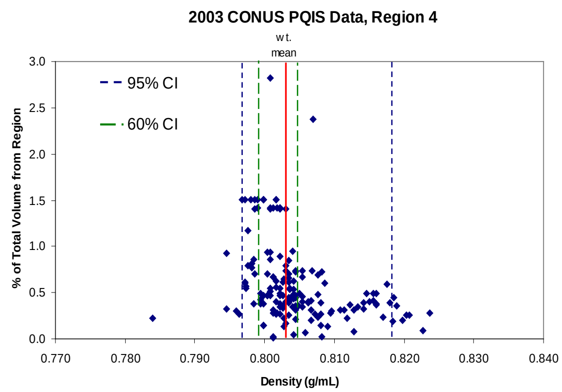
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.0049	(.791, .810)	(.792, .809)	(.794, .806)	(.796, .805)	(.797, .804)	0.960
2000	0.0040	(.792, .808)	(.793, .807)	(.795, .805)	(.796, .804)	(.797, .803)	0.989
2001	0.0048	(.794, .814)	(.796, .812)	(.798, .809)	(.799, .808)	(.799, .807)	0.980
2002	0.0094	(.793, .829)	(.795, .823)	(.797, .817)	(.798, .814)	(.799, .812)	0.984
2003	0.0047	(.795, .813)	(.796, .811)	(.797, .808)	(.798, .807)	(.799, .806)	0.965
2004	0.0041	(.796, .811)	(.797, .809)	(.798, .807)	(.799, .806)	(.799, .805)	0.947
2005	0.0065	(.793, .819)	(.794, .814)	(.795, .810)	(.796, .808)	(.797, .806)	0.971
2006	0.0084	(.792, .823)	(.793, .817)	(.795, .812)	(.796, .809)	(.797, .808)	0.945
2007	0.0130	(.790, .837)	(.792, .828)	(.794, .820)	(.796, .816)	(.797, .813)	0.954
2008	0.0065	(.795, .820)	(.796, .815)	(.797, .811)	(.798, .809)	(.799, .808)	0.968

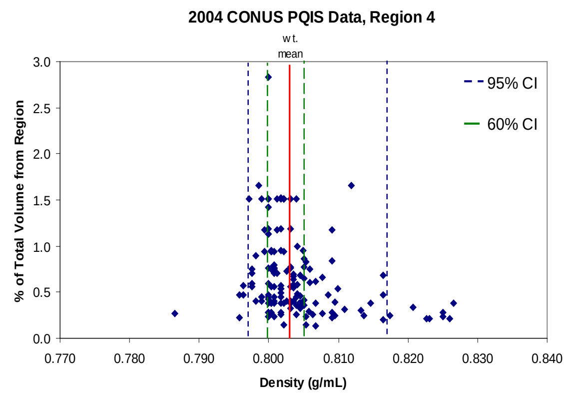


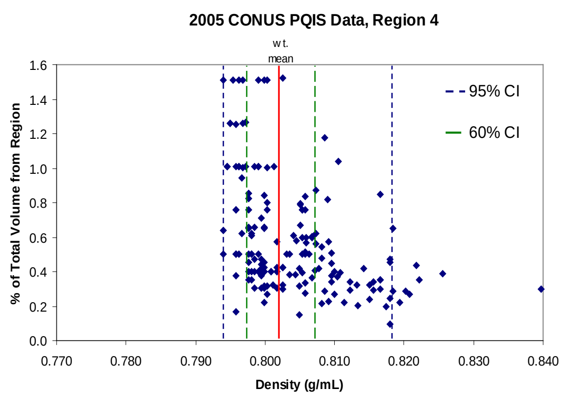


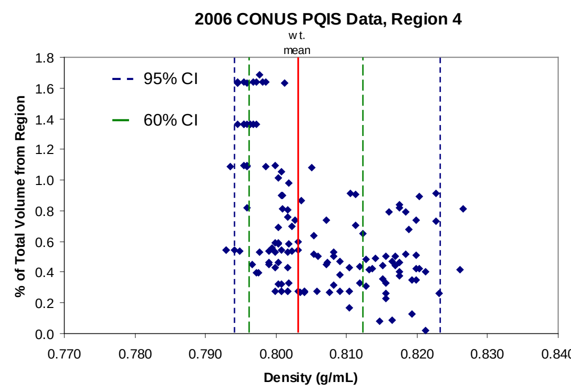

2001 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)

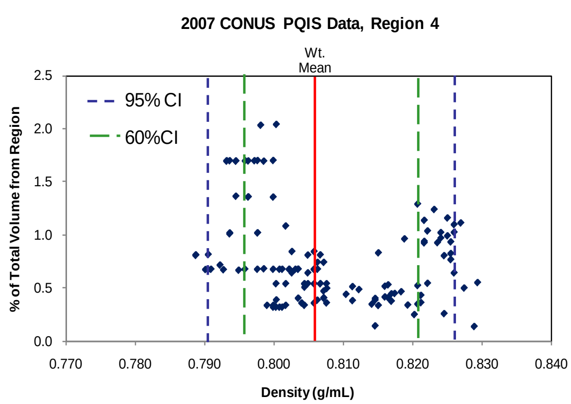

2002 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)

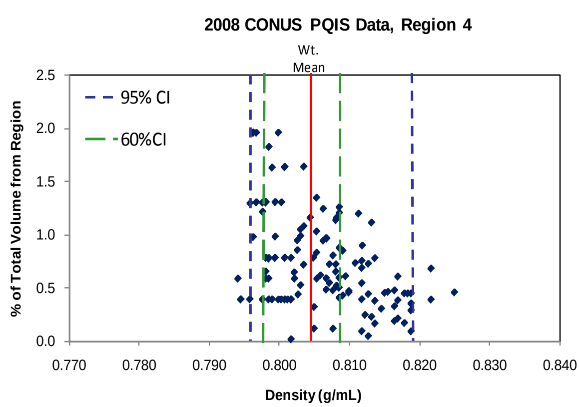

2003 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2004 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2005 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2006 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2007 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)

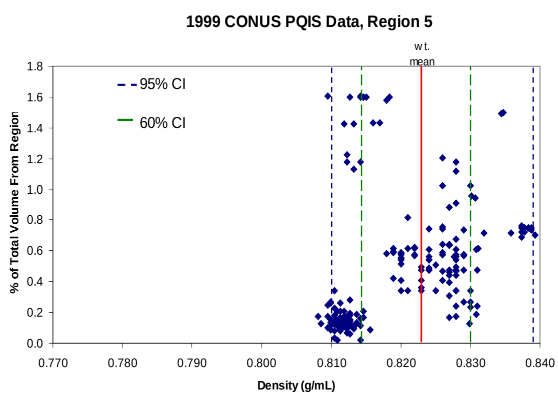

2008 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)

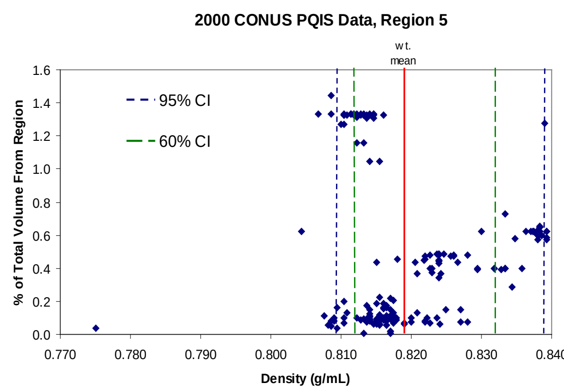
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 5 Based on PQIS Data from 1999-2008.

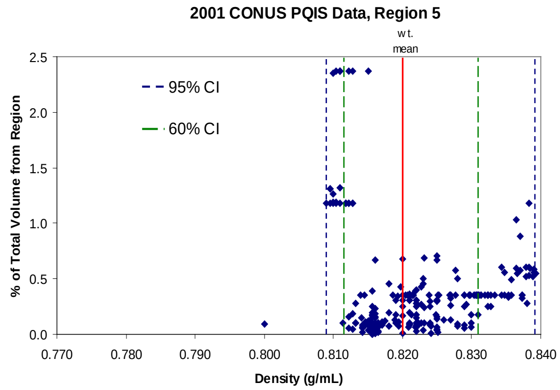
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	0.823	0.0090	(.810, .839)	(.811, .838)	(.812, .836)	(.813, .831)	(.814, .830)
2000	0.819	0.0114	(.809, .839)	(.809, .838)	(.810, .838)	(.811, .837)	(.812, .832)
2001	0.820	0.0080	(.809, .839)	(.809, .838)	(.810, .837)	(.810, .834)	(.811, .831)
2002	0.821	0.0083	(.808, .837)	(.810, .837)	(.810, .835)	(.810, .832)	(.810, .831)
2003	0.822	0.0087	(.803, .838)	(.808, .837)	(.809, .836)	(.810, .835)	(.811, .835)
2004	0.823	0.0087	(.805, .838)	(.807, .837)	(.808, .836)	(.809, .835)	(.810, .834)
2005	0.818	0.0087	(.804, .834)	(.805, .833)	(.807, .832)	(.808, .830)	(.808, .828)
2006	0.818	0.0122	(.807, .831)	(.808, .830)	(.809, .829)	(.810, .828)	(.811, .828)
2007	0.819	0.0097	(.809, .837)	(.809, .836)	(.810, .835)	(.810, .832)	(.811, .831)
2008	0.819	0.0081	(.809, .835)	(.810, .834)	(.812, .832)	(.812, .831)	(.813, .830)

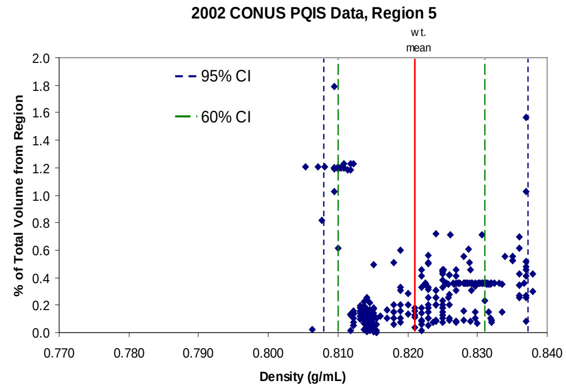
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from Region 5 Based on the Lognormal Distribution of PQIS Data from 1999-2008.

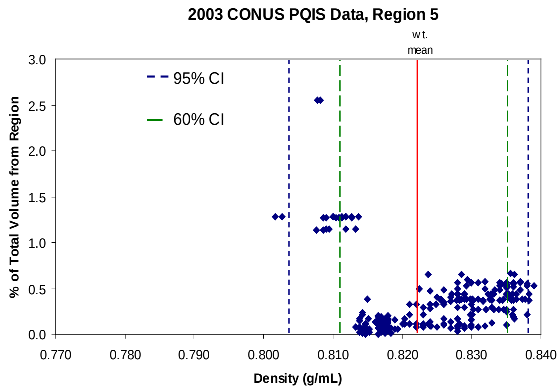
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.0083	(.808, .840)	(.810, .837)	(.813, .834)	(.814, .831)	(.816, .830)	0.975
2000	0.0089	(.804, .838)	(.806, .835)	(.808, .831)	(.810, .828)	(.812, .826)	0.914
2001	0.0093	(.806, .844)	(.807, .839)	(.809, .833)	(.811, .830)	(.812, .828)	0.950
2002	0.0103	(.807, .846)	(.808, .840)	(.810, .834)	(.811, .830)	(.812, .828)	0.950
2003	0.0103	(.802, .843)	(.805, .839)	(.809, .836)	(.812, .833)	(.814, .831)	0.950
2004	0.0104	(.803, .843)	(.806, .840)	(.810, .836)	(.812, .834)	(.814, .832)	0.950
2005	0.0097	(.800, .839)	(.802, .835)	(.805, .831)	(.808, .828)	(.809, .826)	0.973
2006	0.0077	(.805, .835)	(.807, .832)	(.809, .828)	(.811, .826)	(.812, .825)	0.972
2007	0.0088	(.806, .840)	(.808, .835)	(.809, .831)	(.811, .828)	(.812, .825)	0.931
2008	0.0076	(.809, .838)	(.810, .833)	(.811, .829)	(.812, .826)	(.813, .824)	0.946

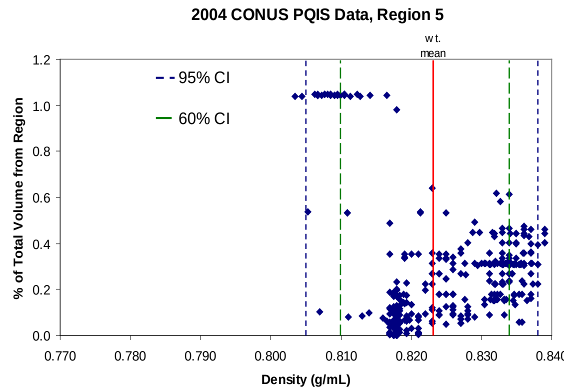


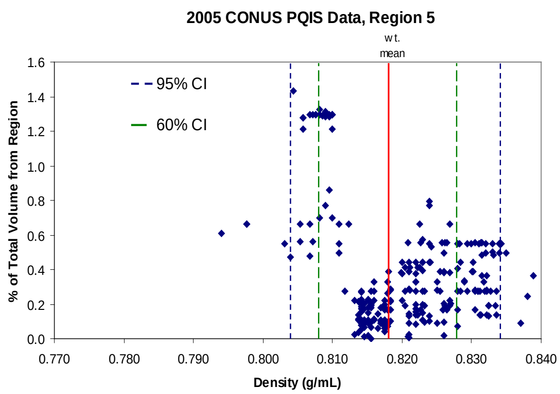


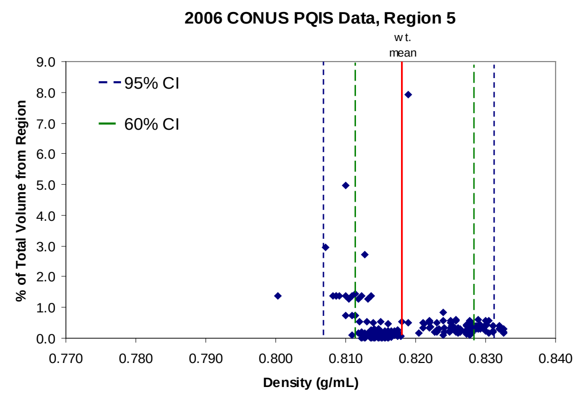

2001 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)

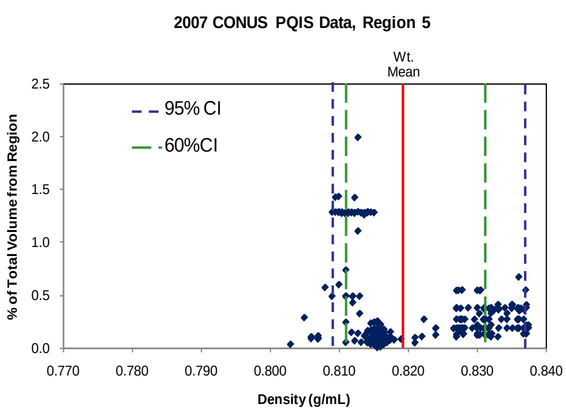

2002 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)

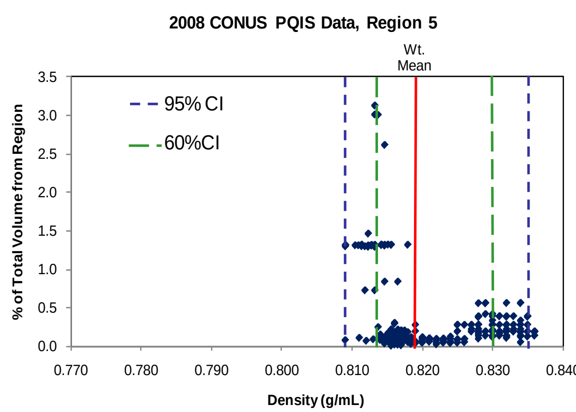

2003 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2004 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2005 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2006 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Density (g/mL)


2007 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)

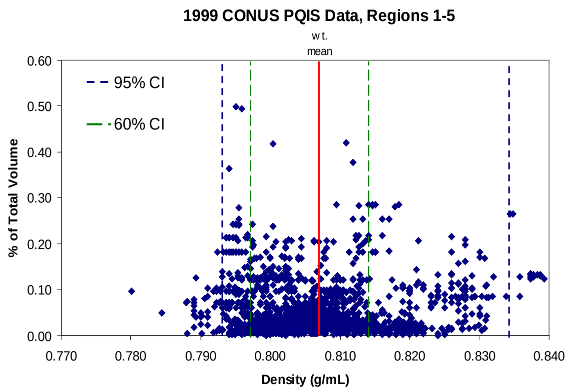

2008 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Density (g/mL)

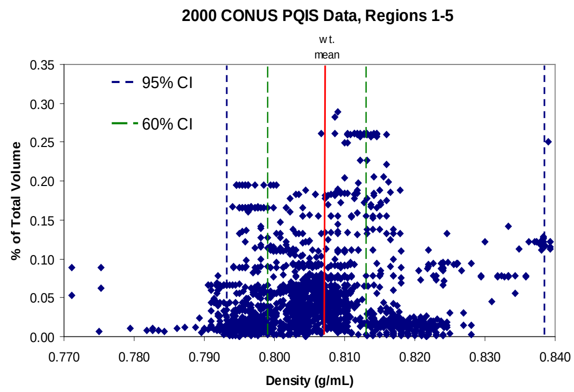
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from CONUS Based on PQIS Data from 1999-2008.

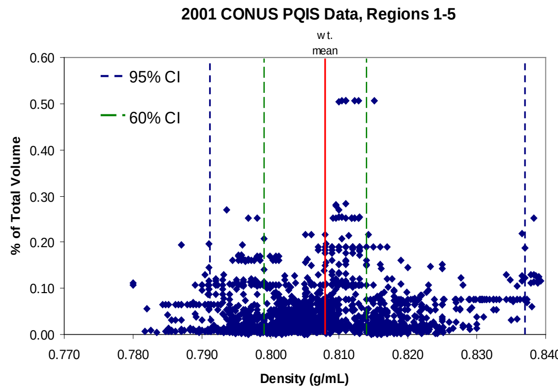
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	0.807	0.0093	(.793, .834)	(.794, .829)	(.795, .824)	(.796, .818)	(.797, .814)
2000	0.807	0.0099	(.793, .838)	(.795, .826)	(.796, .817)	(.797, .815)	(.799, .813)
2001	0.808	0.0103	(.791, .837)	(.792, .831)	(.796, .821)	(.797, .817)	(.799, .814)
2002	0.810	0.0106	(.790, .835)	(.793, .830)	(.799, .824)	(.803, .818)	(.804, .815)
2003	0.809	0.0116	(.790, .836)	(.793, .833)	(.798, .826)	(.801, .816)	(.803, .814)
2004	0.807	0.0132	(.789, .836)	(.791, .834)	(.792, .829)	(.792, .818)	(.793, .815)
2005	0.806	0.0115	(.790, .831)	(.792, .826)	(.793, .818)	(.795, .814)	(.798, .812)
2006	0.807	0.0104	(.790, . 828)	(.792, .826)	(.796, .818)	(.798, .815)	(.800, .813)
2007	0.808	0.0117	(.790, .835)	(.792, .831)	(.794, .822)	(.798, .814)	(.801, .813)
2008	0.807	0.0112	(.791, .832)	(.792, .830)	(.794, .817)	(.797, .815)	(.798, .813)

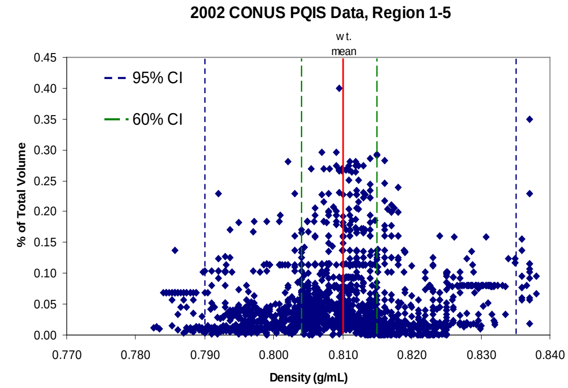
Statistics and Confidence Intervals for the Density (g/mL) of JP-8 Fuel from CONUS Based on the Lognormal Distribution of PQIS Data from 1999-2008.

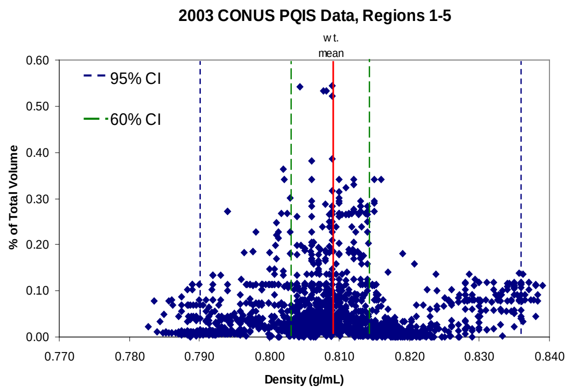
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.0105	(.790, .833)	(.792 .826)	(.795, .821)	(.796, .817)	(.798, .815)	0.990
2000	0.0096	(.790, .828)	(.792, .824)	(.795, .820)	(.797, .817)	(.799, .815)	0.973
2001	0.0106	(.790, .832)	(.793, .828)	(.796, .823)	(.798, .819)	(.799, .817)	0.990
2002	0.0095	(.792, .831)	(.795, .827)	(.798, .823)	(.800, .821)	(.802, .819)	0.979
2003	0.0100	(.792, .832)	(.794, .828)	(.797, .823)	(.799, .820)	(.801, .818)	0.976
2004	0.0125	(.788, .839)	(.790, .832)	(.793, .825)	(.795, .820)	(.797, .817)	0.981
2005	0.0094	(.790, .827)	(.792, .823)	(.795, .819)	(.797, .816)	(.798, .814)	0.986
2006	0.0088	(.791, .826)	(.794,.823)	(.796, .819)	(.783, .817)	(.800, .815)	0.990
2007	0.0101	(.791, .831)	(.793, .826)	(.796, .820)	(.798, .817)	(.800, .815)	0.977
2008	0.0096	(.791, .830)	(.793, .826)	(.796, .821)	(.798, .818)	(.799, .816)	0.988

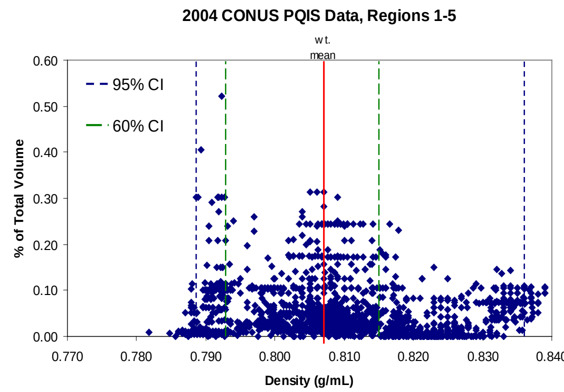


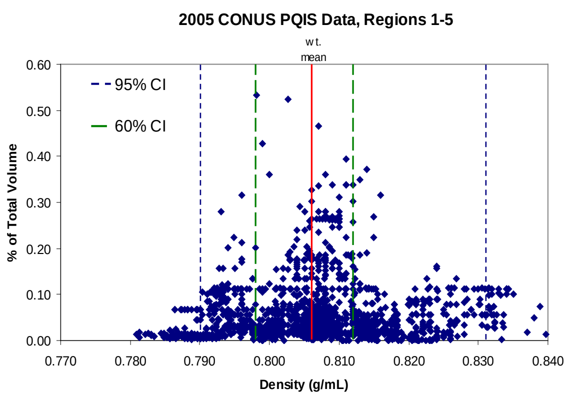


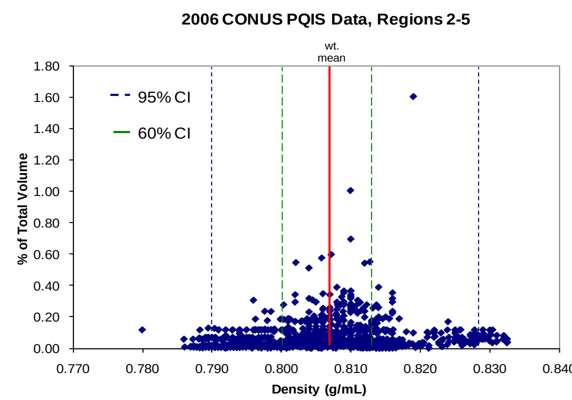

2001 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Density (g/mL)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840

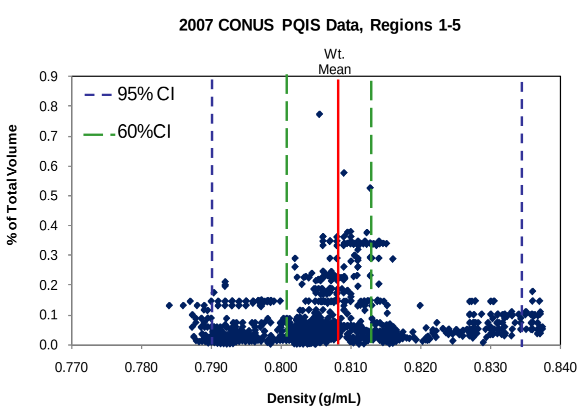

2002 CONUS PQIS Data, Region 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Density (g/mL)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840

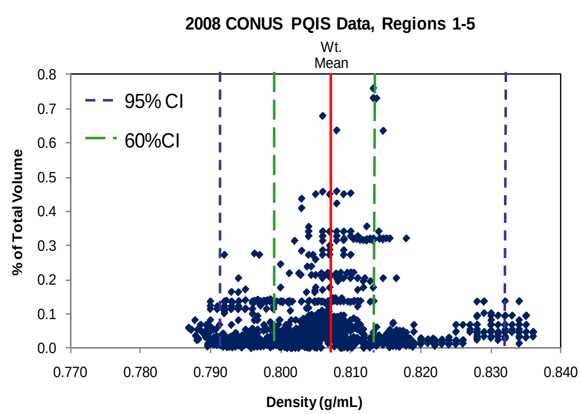

2003 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Density (g/mL)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2004 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Density (g/mL)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2005 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Density (g/mL)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2006 CONUS PQIS Data, Regions 2-5
wt.
mean
95% CI
60% CI
% of Total Volume
Density (g/mL)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2007 CONUS PQIS Data, Regions 1-5
Wt.
Mean
95% CI
60%CI
% of Total Volume
Density (g/mL)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840


2008 CONUS PQIS Data, Regions 1-5
Wt.
Mean
95% CI
60%CI
% of Total Volume
Density (g/mL)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.770
0.780
0.790
0.800
0.810
0.820
0.830
0.840

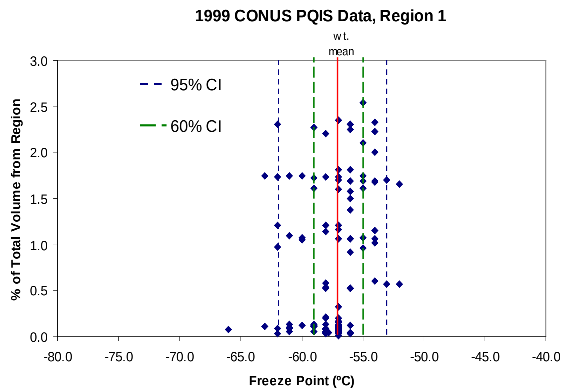
7.3 Freeze Point

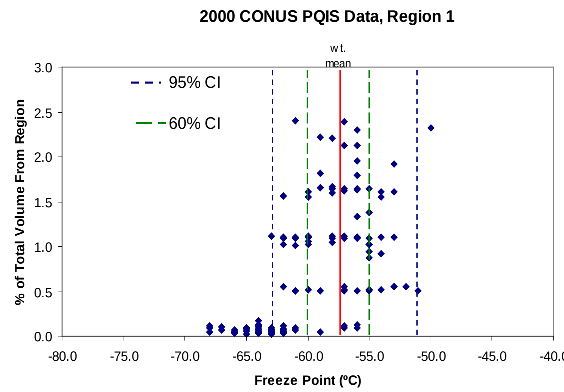
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 1 Based on PQIS Data from 1999-2007.

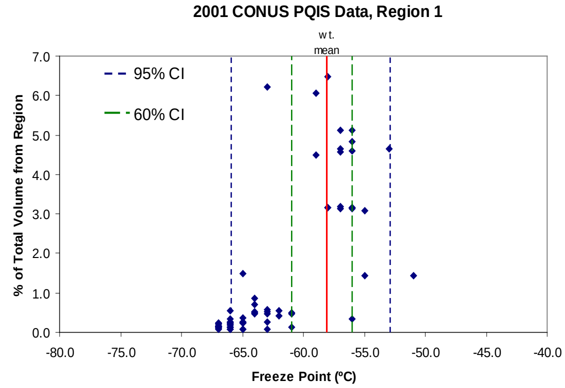
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	-56.9	2.26	(-62.0, -53.0)	(-62.0, -54.0)	(-61.0, -54.0)	(-60.0, -54.0)	(-59.0, -55.0)
2000	-57.4	4.74	(-63.0, -51.0)	(-62.0, -53.0)	(-61.0, -54.0)	(-61.0, -55.0)	(-60.0, -55.0)
2001	-58.2	6.18	(-66.0, -53.0)	(-65.0, -53.0)	(-64.0, -55.0)	(-63.0, -56.0)	(-61.0, -56.0)
2002	-61.0	7.50	(-66.0, -47.8)	(-66.0, -49.4)	(-66.0, -51.5)	(-66.0, -52.6)	(-66.0, -53.1)
2003	-58.0	5.97	(-66.0, -48.5)	(-66.0, -50.0)	(-66.0, -52.0)	(-65.0, -53.5)	(-62.3, -55.0)
2004	-53.4	8.12	(-58.6, -48.7)	(-58.6, -49.5)	(-57.0, -49.9)	(-56.4, -50.4)	(-55.7, -51.1)
2005	-49.4	5.84	(-52.0, -47.3)	(-52.0, -48.9)	(-52.0, -48.9)	(-49.6, -48.9)	(-49.6, -48.9)
2007	-49.7	1.24	(-51.5, -48.9)	(-51.5, -48.9)	(-51.0, -48.9)	(-51.0, -48.9)	(-51.0, -48.9)

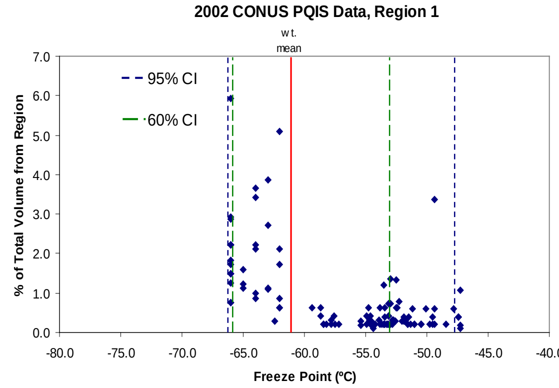
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 1 Based on the Weibull Distribution of PQIS Data from 1999-2007.

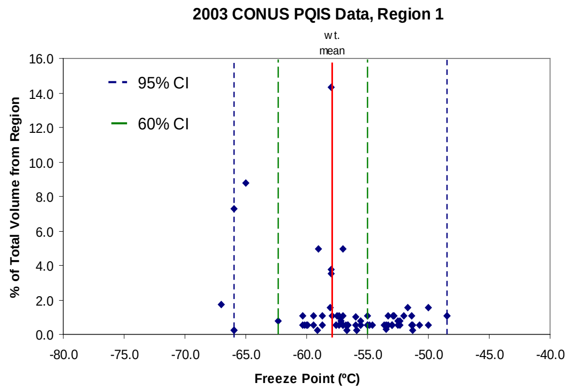
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	2.47	(-62.4, -52.7)	(-61.3, -53.2)	(-60.2, -53.9)	(-59.4, -54.4)	(-58.9, -54.8)	0.978
2000	2.93	(-63.7, -52.3)	(-62.6, -53.0)	(-61.3, -53.8)	(-60.5, -54.4)	(-59.9, -54.9)	0.988
2001	3.26	(-65.9, -53.2)	(-64.3, -53.8)	(-62.5, -54.5)	(-61.4, -55.0)	(-60.6, -55.5)	0.959
2002	4.59	(-66.2, -49.5)	(-66.1, -52.8)	(-65.9, -56.1)	(-65.7, -58.0)	(-65.4, -59.3)	0.887
2003	5.47	(-66.3, -45.6)	(-65.6, -47.9)	(-64.6, -50.6)	(-63.7, -52.3)	(-62.9, -53.6)	0.942
2004	2.71	(-58.7, -48.3)	(-58.0, -49.1)	(-57.1, -50.1)	(-56.5, -50.7)	(-56.0, -51.3)	0.988
2005	1.07	(-51.9, -47.8)	(-51.4, -48.0)	(-50.8, -48.2)	(-50.4, -48.3)	(-50.1, -48.5)	0.851
2007	1.21	(-51.4, -46.9)	(-51.3, -47.4)	(-51.1, -48.1)	(-50.9, -48.5)	(-50.8, -48.8)	0.898

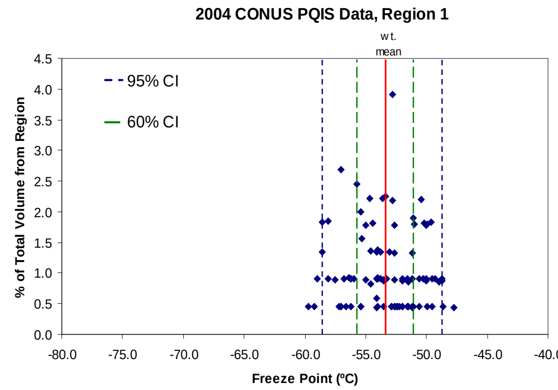


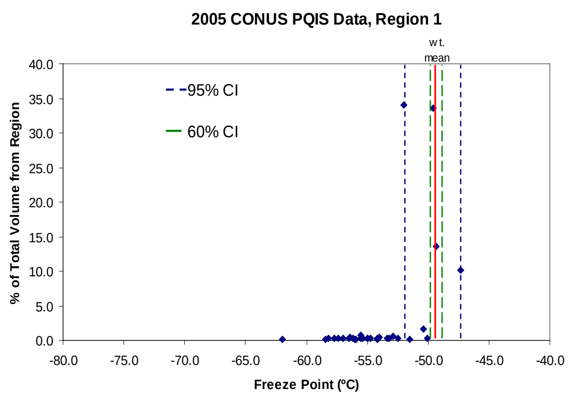


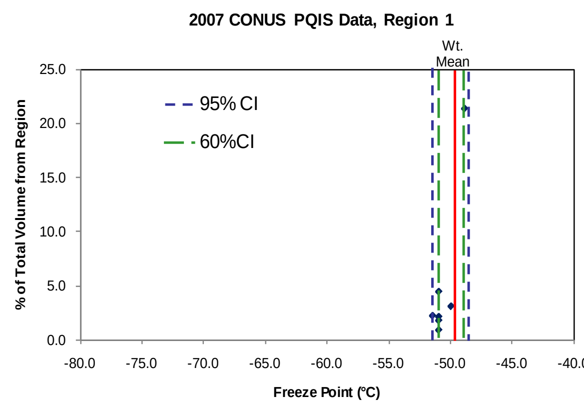

2001 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2002 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2003 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2004 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2005 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

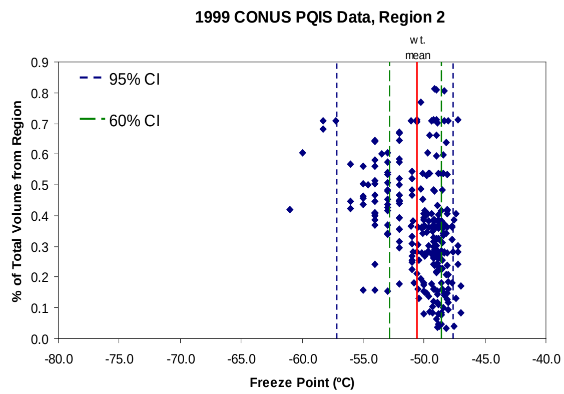

2007 CONUS PQIS Data, Region 1
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

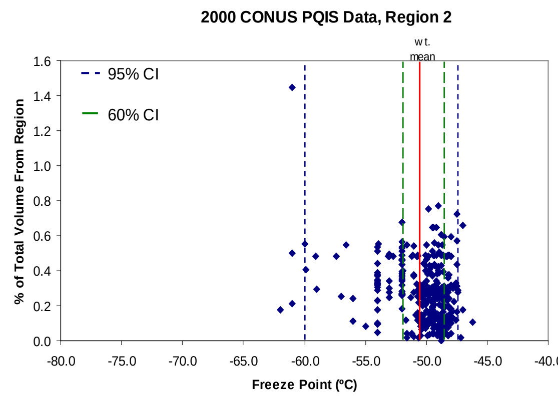
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 2 Based on PQIS Data from 1999-2008.

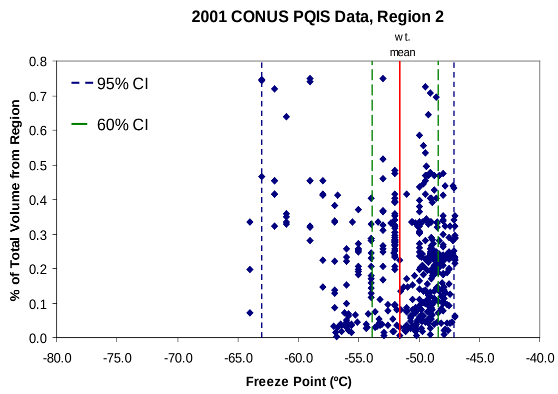
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	-50.6	2.36	(-57.2, -47.5)	(-55.0, -48.0)	(-54.0, -48.2)	(-53.0, -48.4)	(-53.0, -48.6)
2000	-50.5	2.42	(-60.0, -47.5)	(-56.6, -47.8)	(-54.0 -48.1)	(-53.0, -48.4)	(-52.0, -48.6)
2001	-51.6	3.59	(-63.0, -47.0)	(-62.0, -47.5)	(-59.0, -48.0)	(-56.0, -48.2)	(-54.0, -48.5)
2002	-51.3	3.44	(-63.0, -47.3)	(-61.0, -47.9)	(-59.0, -48.0)	(-54.9, -48.5)	(-53.8, -48.8)
2003	-50.0	6.60	(-65.0, -47.1)	(-57.4, -47.3)	(-53.6, -47.8)	(-51.1, -48.0)	(-50.5, -48.0)
2004	-50.0	7.74	(-63.0, -47.2)	(-57.0, -47.6)	(-53.0, -47.9)	(-51.3, -48.0)	(-50.1, -48.1)
2005	-49.8	3.46	(-54.1, -47.8)	(-53.4, -47.8)	(-52.1, -48.2)	(-51.6, -48.5)	(-50.8, -48.6)
2006	-50.3	2.06	(-54.6, -47.8)	(-53.5, -48.1)	(-52.2, -48.3)	(-52.0, -48.5)	(-51.4, -49.0)
2007	-51.5	2.00	(-55.6, -47.8)	(-54.7, -47.8)	(-54.6, -48.3)	(-53.8, -49.1)	(-53.3, -49.5)
2008	-51.9	2.52	(-56.7, -47.6)	(-55.9, -47.8)	(-54.6, -48.3)	(-54.5, -48.6)	(-54.2, -49.3)

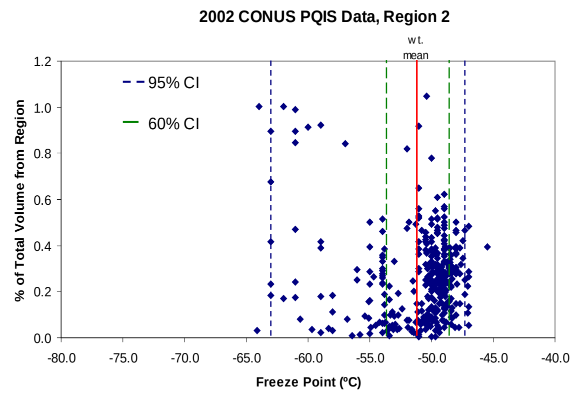
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 2 Based on the Smallest Extreme Value Distribution of PQIS Data from 1999-2008.

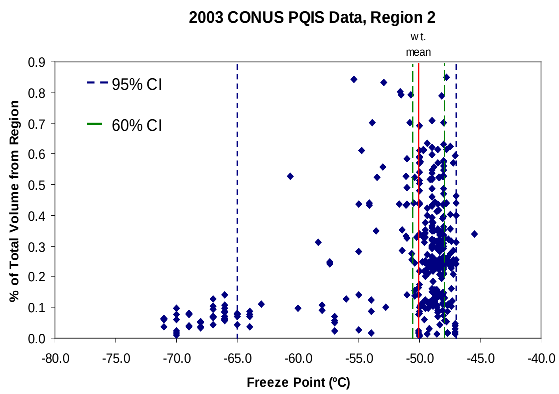
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	2.52	(-56.7, -46.9)	(-55.3, -47.3)	(-53.9, -47.8)	(-53.0, -48.2)	(-52.4, -48.5)	0.984
2000	2.70	(-57.0, -46.6)	(-55. 6, -47.0)	(-54.1, -47.6)	(-53.1, -48.0)	(-52.5, -48.3)	0.961
2001	4.02	(-61.3, -45.7)	(-59.1, -46.3)	(-56.8, -47.2)	(-55.5, -47.8)	(-54.5, -48.3)	0.963
2002	3.82	(-60.5, -45.7)	(-58.4, -46.3)	(-56.3, -47.1)	(-55.0, -47.7)	(-54.1, -48.2)	0.935
2003	3.34	(-58.1, -45.1)	(-56.2, -45.6)	(-54.4, -46.3)	(-53.2, -46.8)	(-52.4, -47.3)	0.891
2004	3.30	(-58.0, -47.1)	(-56.1, -45.7)	(-54.3, -46.4)	(-53.2, -46.8)	(-52.4, -47.3)	0.868
2005	1.99	(-54.6, -46.9)	(-53.6, -47.3)	(-52.4, -47.7)	(-51.8, -48.0)	(-51.3, -48.2)	0.948
2006	2.04	(-55.2, -47.3)	(-54.1, -47.7)	(-53.0, -48.1)	(-52.3, -48.4)	(-51.8, -48.6)	0.912
2007	2.14	(-56.6, -48.3)	(-55.5, -48.7)	(-54.3, -49.1)	(-53.5, -49.4)	(-53.0, -49.7)	0.974
2008	2.39	(-57.7, -48.4)	(-56.4, -48.8)	(-55.1, -49.3)	(-54.2, -49.7)	(-53.7, -50.0)	0.936

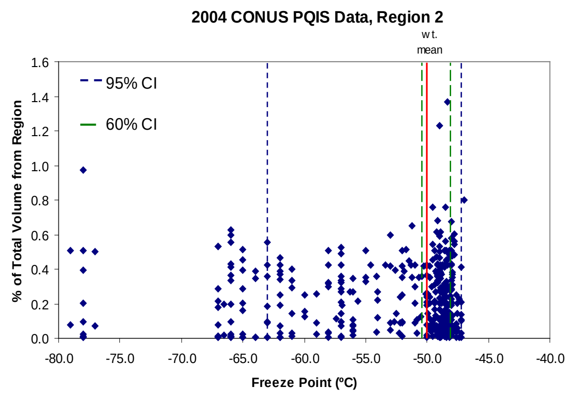


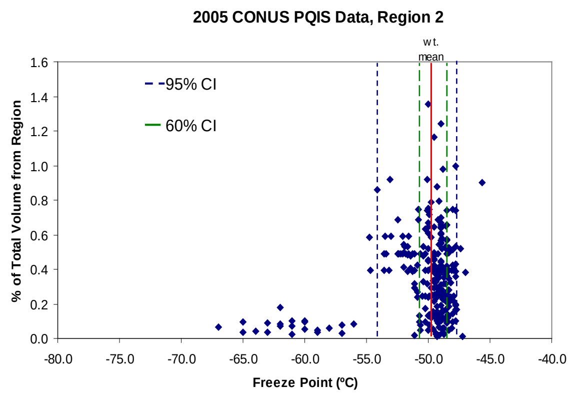


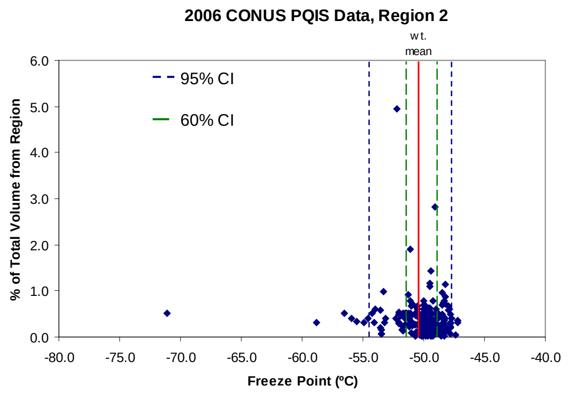

2001 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

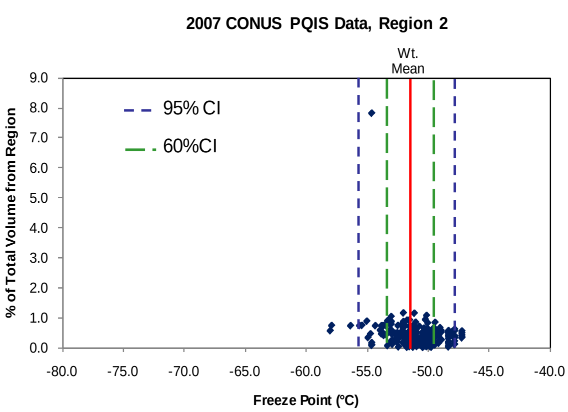

2002 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

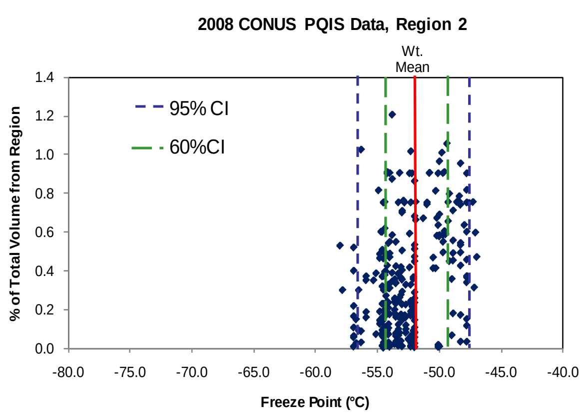

2003 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2004 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2005 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2006 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2007 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

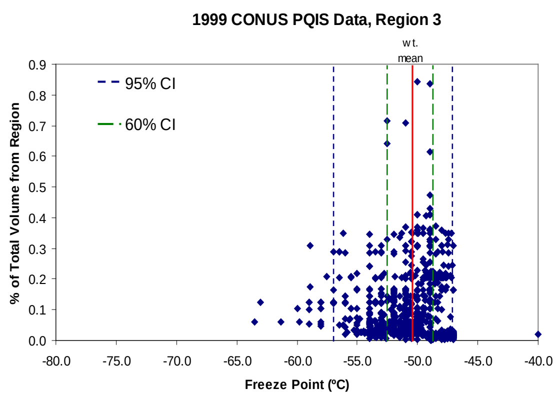

2008 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

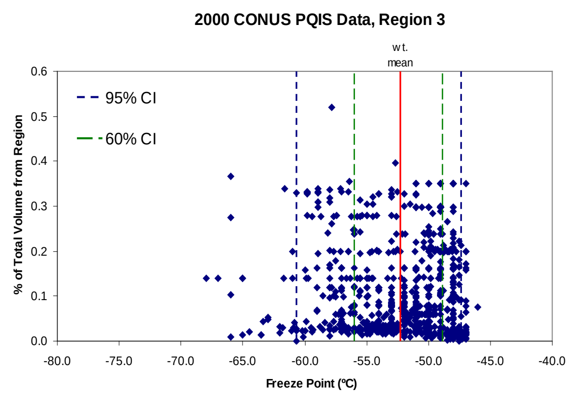
Statistics and Confidence Intervals for the Freeze Point (°C) of JP-8 Fuel from Region 3 Based on PQIS Data from 1999-2008.

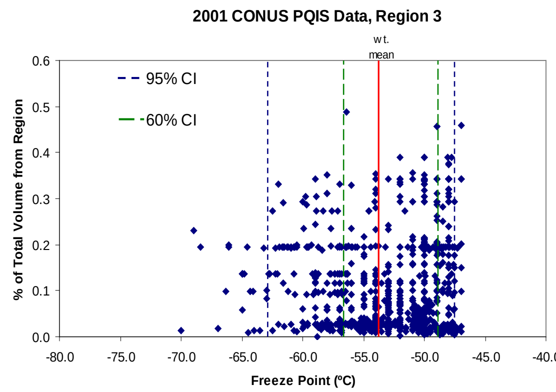
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	-50.5	2.75	(-57.0, -47.2)	(-56.0, -47.5)	(-54.0, -48.0)	(-53.0, -48.3)	(-52.5, -48.8)
2000	-52.3	3.94	(-60.7, -47.4)	(-59.8, -48.0)	(-58.0, -48.0)	(-57.0, -48.5)	(-56.0, -49.0)
2001	-52.7	4.22	(-62.8, -47.5)	(-61.6, -47.8)	(-59.0, -48.0)	(-57.8, -48.0)	(-56.7, -48.8)
2002	-52.6	4.61	(-62.0, -47.0)	(-61.4, -47.5)	(-60.0, -48.0)	(-57.8, -48.0)	(-56.0, -48.5)
2003	-52.9	4.61	(-64.0, -47.5)	(-61.4, -48.0)	(-60.0, -48.3)	(-58.8, -48.8)	(-57.0, -49.0)
2004	-50.7	3.02	(-60.0, -47.7)	(-57.0, -47.9)	(-54.7, -48.0)	(-54.0, -48.0)	(-53.0, -48.2)
2005	-51.3	3.38	(-60.0, -47.0)	(-58.0, -47.5)	(-56.8, -48.0)	(-55.0, -48.0)	(-54.0, -48.3)
2006	-51.9	3.38	(-60.7, -47.7)	(-60.0, -47.9)	(-57.0, -48.2)	(-56.0, -48.4)	(-55.0, -48.7)
2007	-52.1	3.42	(-60.0, -47.3)	(-59.0, -47.6)	(-57.0, -48.0)	(-56.0, -48.5)	(-55.6, -48.9)
2008	-51.4	4.06	(-60.0, -47.3)	(-58.1, -47.5)	(-56.4, -48.0)	(-55.1, -48.2)	(-53.8, -48.5)

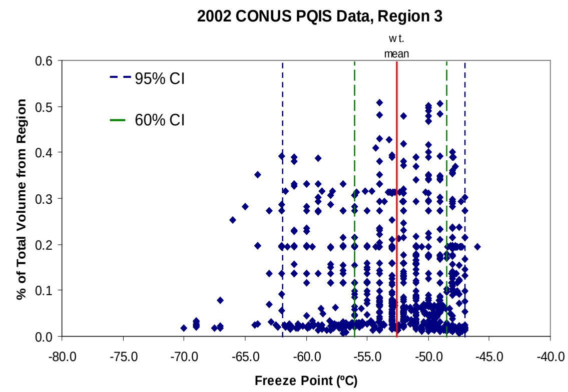
Statistics and Confidence Intervals for the Freeze Point (°C) of JP-8 Fuel from Region 3 Based on the Smallest Extreme Value Distribution of PQIS Data from 1999-2008.

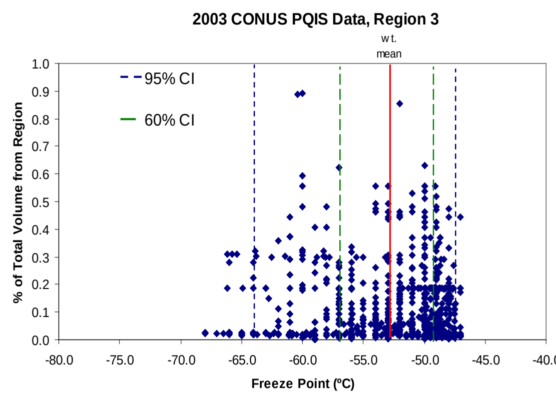
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	2.57	(-56.8, -46.8)	(-55.4, -47.3)	(-54.0, -47.8)	(-53.1, -48.2)	(-52.5, -48.5)	0.991
2000	3.97	(-61.9, -46.5)	(-59.7, -47.1)	(-57.4, -47.9)	(-56.1, -48.5)	(-55.2, -49.0)	0.984
2001	4.43	(-63.4, -46.2)	(-60.9, -46.9)	(-58.4, -47.8)	(-56.9, -48.5)	(-55.9, -49.0)	0.985
2002	4.41	(-63.3, -46.2)	(-60.8, -46.9)	(-58.4, -47.8)	(-56.9, -48.4)	(-55.8, -49.0)	0.988
2003	4.47	(-63.7, -46.3)	(-61.2, -47.1)	(-58.7, -48.0)	(-57.2, -48.7)	(-56.1, -49.2)	0.977
2004	3.01	(-58.0, -46.3)	(-56.3, -46.8)	(-54.6, -47.4)	(-53.6, -47.8)	(-52.9, -48.2)	0.975
2005	3.38	(-59.5, -46.4)	(-57.6, -46.9)	(-55.7, -47.6)	(-54.6, -48.1)	(-53.7, -48.5)	0.984
2006	3.86	(-61.2, -46.2)	(-59.1, -46.9)	(-56.9, -47.7)	(-55.6, -48.2)	(-54.7, -48.7)	0.985
2007	3.38	(-60.3, -47.2)	(-58.5, -47.7)	(-56.6, -48.4)	(-55.4, -48.9)	(-54.6, -49.4)	0.970
2008	3.37	(-59.5, -46.4)	(-57.7, -47.0)	(-55.8, -47.7)	(-54.6, -48.2)	(-53.8, -48.6)	0.987

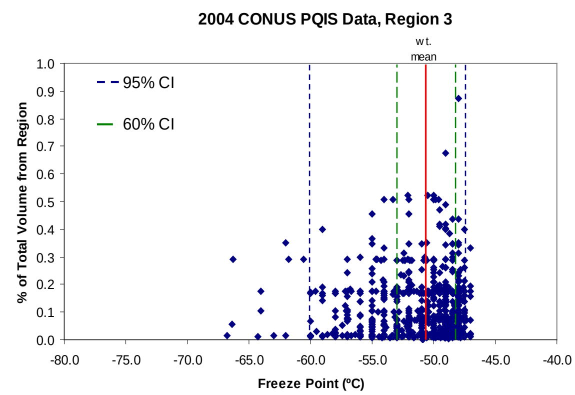


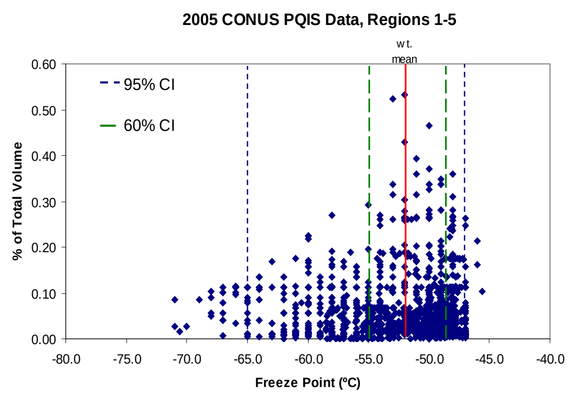


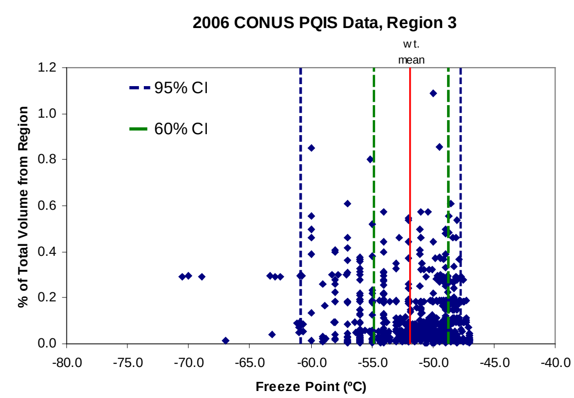

2001 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

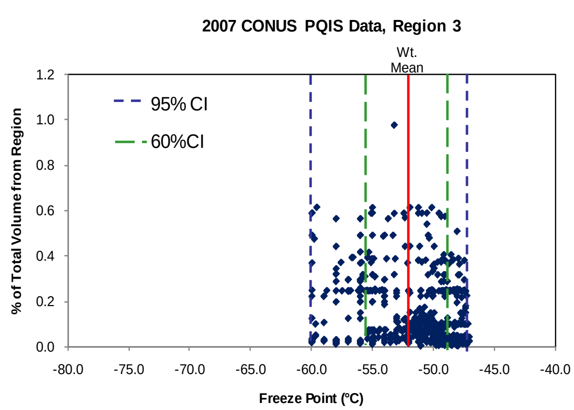

2002 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

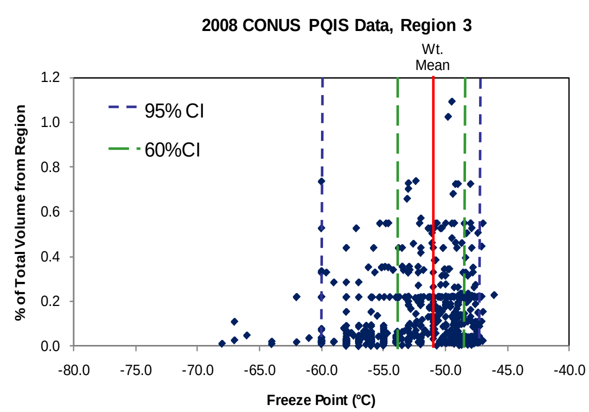

2003 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2004 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2005 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Freeze Point (ºC)


2006 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2007 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

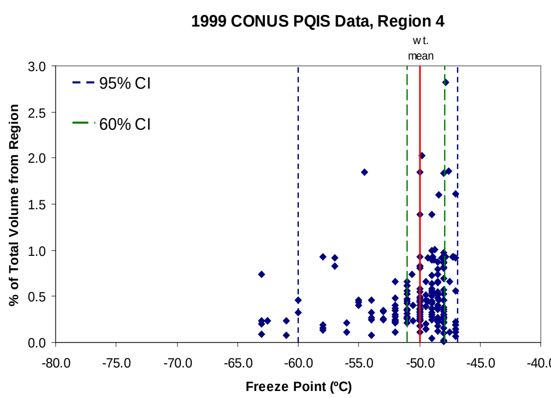

2008 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

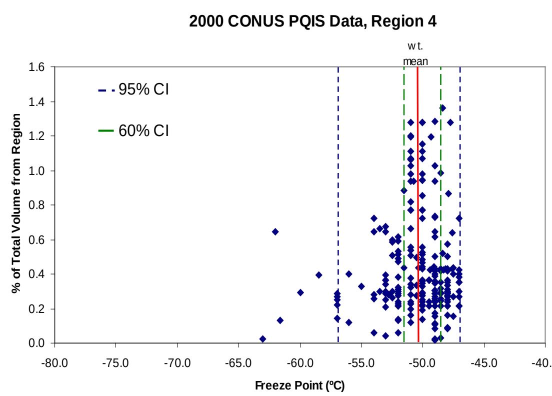
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 4 Based on PQIS Data from 1999-2008.

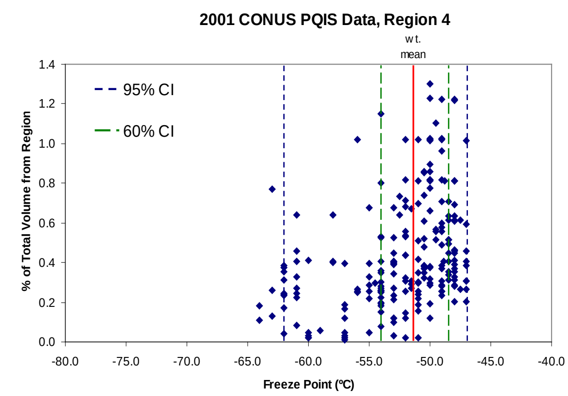
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	-50.0	3.53	(-60.0, -47.0)	(-57.0, -47.2)	(-54.0, -47.8)	(-52.0, -48.0)	(-51.0, -48.0)
2000	-50.3	2.65	(-57.0, -47.0)	(-54.0, -47.6)	(-53.0, -48.0)	(-52.0, -48.3)	(-51.5, -48.5)
2001	-51.3	4.45	(-62.0, -47.0)	(-61.0, -48.0)	(-56.0, -48.0)	(-54.0, -48.0)	(-54.0, -48.5)
2002	-50.5	3.34	(-59.0, -47.5)	(-57.0, -47.5)	(-54.0, -48.0)	(-52.5, -48.0)	(-52.0, -48.6)
2003	-51.2	3.20	(-63.0, -48.0)	(-58.0, -48.0)	(-55.0, -49.0)	(-54.0, -49.0)	(-53.0, -49.0)
2004	-49.5	2.75	(-59.0, -47.0)	(-52.4, -47.0)	(-51.5, -48.0)	(-51.0, -48.0)	(-50.0, -48.0)
2005	-49.8	2.80	(-57.0, -47.0)	(-53.5, -47.0)	(-51.5, -48.0)	(-51.5, -48.0)	(-51.0, -48.0)
2006	-51.9	4.36	(-61.0, -48.0)	(-59.0, -48.5)	(-57.5, -49.0)	(-55.5, -49.2)	(-54.5, -49.4)
2007	-52.1	3.42	(-62.0, -48.0)	(-59.0, -48.5)	(-56.0, -48.9)	(-55.5, -49.0)	(-55.0, -49.1)
2008	-52.2	4.53	(-60.7, -47.4)	(-59.0, -47.4)	(-58.0, -48.0)	(-57.0, -48.2)	(-56.0, -48.5)

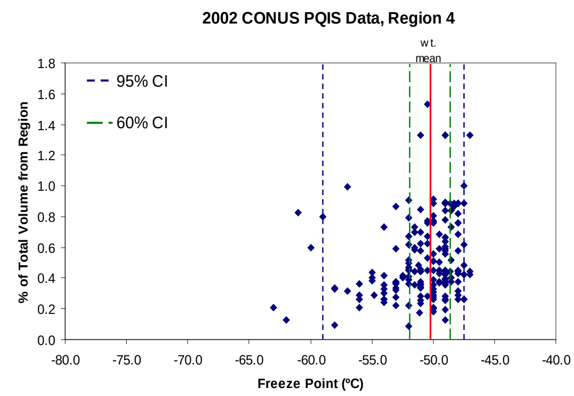
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 4 Based on the Smallest Extreme Value Distribution of PQIS Data from 1999-2008.

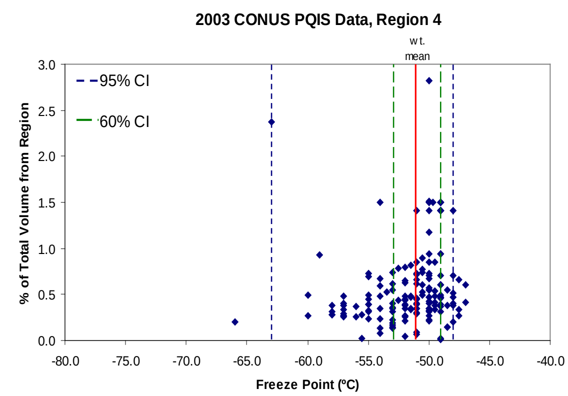
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	2.84	(-56.9, -45.8)	(-55.3, -46.3)	(-53.7, -46.9)	(-52.7, -47.3)	(-52.0, -47.7)	0.945
2000	2.19	(-55.6, -47.1)	(-54.4, -47.5)	(-53.2, -47.9)	(-52.4, -48.2)	(-51.9, -48.5)	0.977
2001	3.59	(-60.0, -46.1)	(-58.0, -46.7)	(-56.0, -47.4)	(-54.8, -48.0)	(-53.9, -48.4)	0.968
2002	2.99	(-57.8, -46.2)	(-56.1, -46.6)	(-54.4, -47.3)	(-53.4, -47.7)	(-52.7, -48.1)	0.935
2003	3.08	(-58.6, -46.7)	(-56.9, -47.2)	(-55.2, -47.8)	(-54.2, -48.3)	(-53.4, -48.7)	0.964
2004	2.37	(-55.2, -46.0)	(-53.9, -46.4)	(-52.6, -46.9)	(-51.8, -47.3)	(-51.2, -47.6)	0.890
2005	2.18	(-55.0, -46.6)	(-53.8, -46.9)	(-52.6, -47.4)	(-51.9, -47.7)	(-51.3, -48.0)	0.956
2006	3.67	(-60.8, -46.6)	(-58.8, -47.1)	(-56.7, -47.9)	(-55.5, -48.5)	(-54.6, -48.9)	0.966
2007	3.59	(-60.7, -46.8)	(-58.8, -47.4)	(-56.7, -48.1)	(-55.5, -48.6)	(-54.6, -49.1)	0.979
2008	3.88	(-61.6, -46.5)	(-59.5, -47.2)	(-57.3, -48.0)	(-56.0, -48.6)	(-55.0, -49.0)	0.980

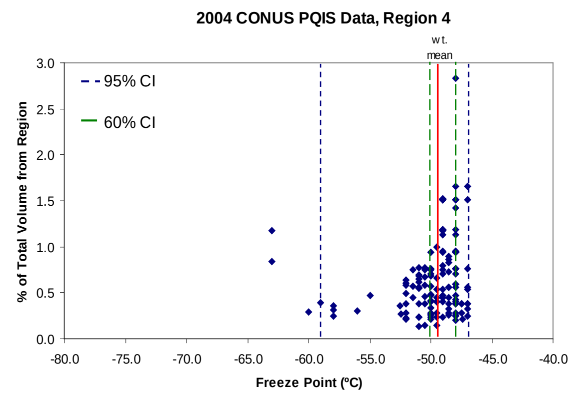


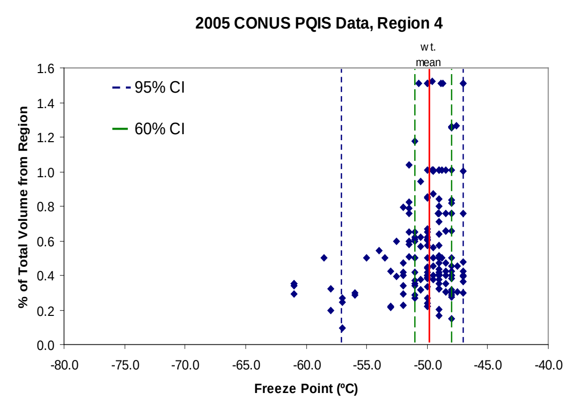


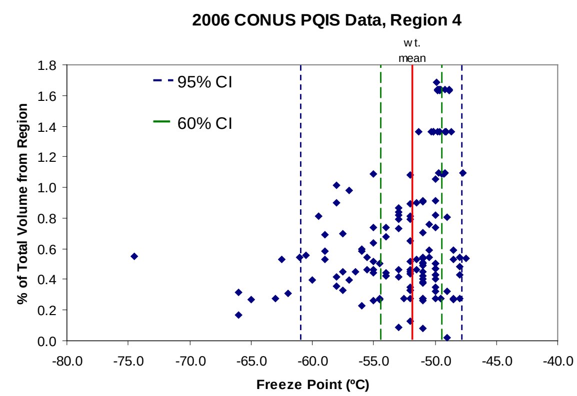

2001 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

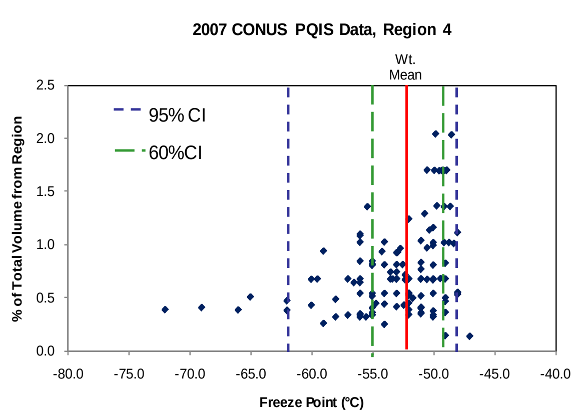

2002 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

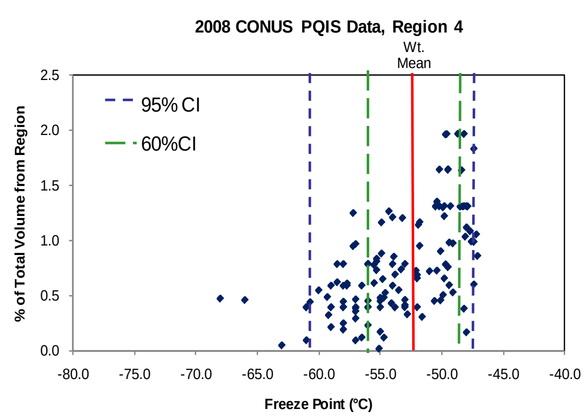

2003 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2004 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2005 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2006 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2007 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

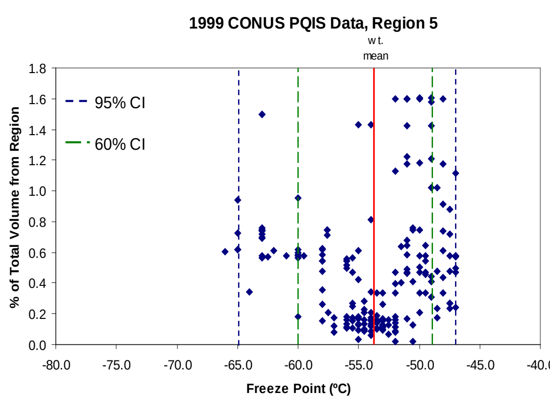

2008 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

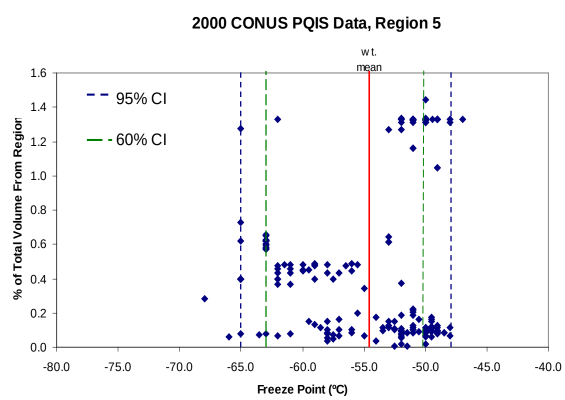
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 5 Based on PQIS Data from 1999-2008.

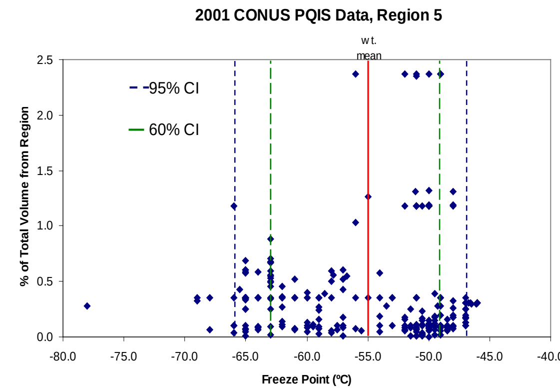
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	-53.9	4.67	(-65.0, -47.0)	(-63.0, -47.5)	(-63.0, -48.0)	(-62.5, -48.5)	(-60.0, -49.0)
2000	-54.6	5.64	(-65.0, -48.0)	(-65.0, -49.0)	(-63.0, -49.0)	(-63.0, -49.0)	(-63.0, -50.2)
2001	-55.0	6.79	(-66.0, -47.0)	(-65.0, -47.0)	(-65.0, -48.0)	(-64.0, -49.0)	(-63.0, -49.0)
2002	-55.4	7.19	(-70.0, -47.0)	(-66.0, -48.0)	(-65.0, -48.0)	(-65.0, -48.0)	(-62.5, -49.0)
2003	-57.0	7.37	(-69.0, -47.0)	(-68.0, -48.5)	(-66.0, -49.0)	(-66.0, -50.0)	(-64.0, -50.0)
2004	-54.8	6.45	(-71.0, -47.0)	(-69.0, -48.0)	(-65.0, -48.0)	(-63.0, -48.5)	(-61.0, -49.0)
2005	-56.0	6.42	(-68.0, -48.0)	(-67.0, -48.0)	(-65.0, -48.0)	(-64.0, -49.0)	(-62.0, -50.0)
2006	-54.4	6.34	(-67.0, -47.5)	(-64.0, -48.0)	(-63.0, -48.6)	(-61.0, -49.0)	(-60.0, -49.0)
2007	-55.2	5.92	(-65.0, -48.5)	(-64.0, -49.0)	(-62.0, -50.0)	(-60.0, -50.4)	(-60.0, -51.0)
2008	-53.0	7.18	(-65.0, -47.9)	(-64.0, -48.0)	(-62.0, -48.1)	(-60.0, -48.6)	(-60.0, -48.6)

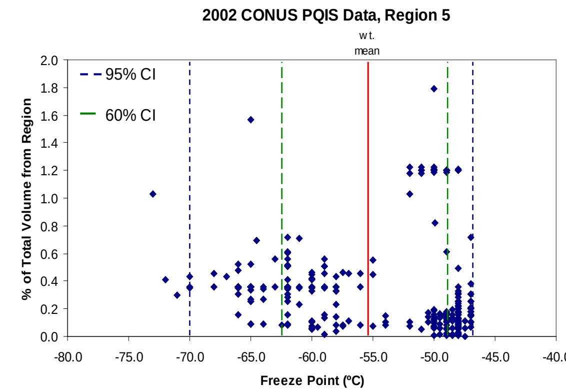
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from Region 5 Based on the Weibull Distribution of PQIS Data from 1999-2008.

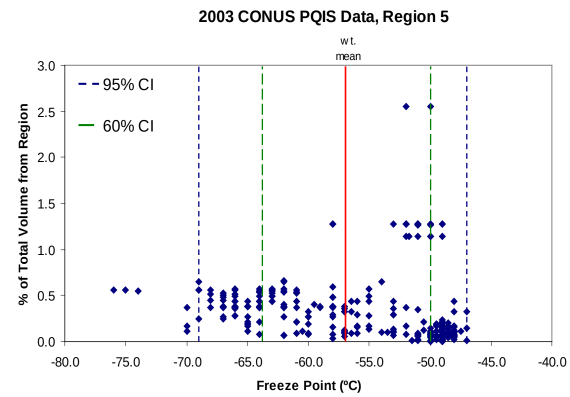
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	6.05	(-64.3, -41.2)	(-63.2, -43.3)	(-61.6, -45.8)	(-60.4, -47.5)	(-59.3, -48.8)	0.955
2000	6.17	(-55.1, -31.5)	(-54.0, -33.8)	(-52.4, -36.3)	(-51.2, -38.1)	(-50.1, -39.4)	0.931
2001	6.26	(-68.4, -44.0)	(-66.1, -45.5)	(-63.4, -47.3)	(-61.6, -48.6)	(-60.2, -49.6)	0.946
2002	7.40	(-69.2, -40.6)	(-67.3, -42.9)	(-65.0, -45.6)	(-63.3, -47.5)	(-61.9, -49.0)	0.958
2003	7.11	(-71.0, -43.5)	(-68.9, -45.5)	(-66.4, -47.9)	(-64.6, -49.5)	(-63.1, -50.8)	0.972
2004	6.85	(-71.0, -44.3)	(-67.5, -45.6)	(-63.9, -47.1)	(-61.6, -48.2)	(-60.0, -49.1)	0.979
2005	6.57	(-67.8, -42.6)	(-66.4, -44.8)	(-64.5, -47.3)	(-63.0, -49.0)	(-61.9, -50.4)	0.981
2006	5.76	(-67.7, -45.2)	(-65.0, -46.3)	(-62.1, -47.7)	(-60.3, -48.7)	(-58.9, -49.6)	0.981
2007	4.97	(-66.3, -46.8)	(-64.2, -47.9)	(-61.9, -49.2)	(-60.4, -50.2)	(-59.2, -50.9)	0.965
2008	6.54	(-64.5, -39.4)	(-63.1, -41.7)	(-61.3, -44.3)	(-60.0, -46.1)	(-58.8, -47.5)	0.931

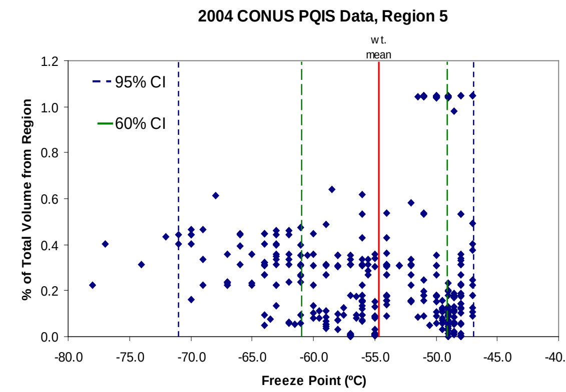


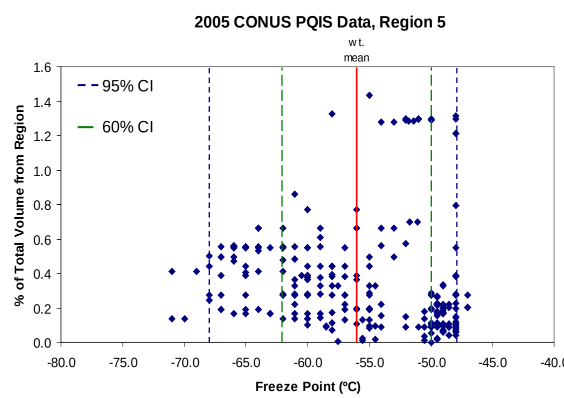


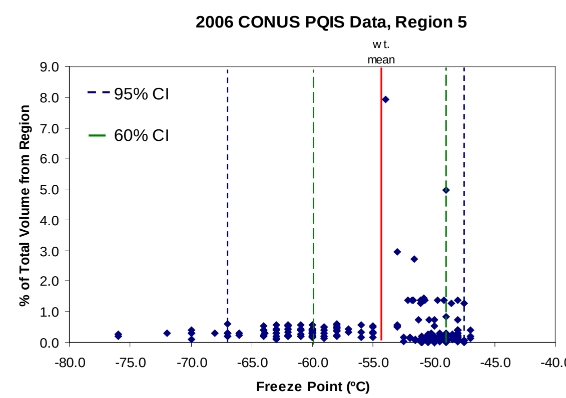

2001 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

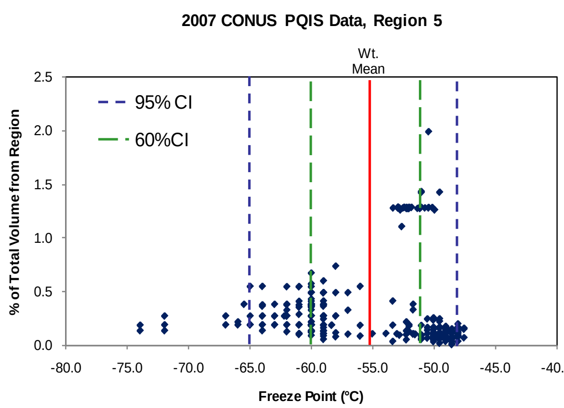

2002 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)

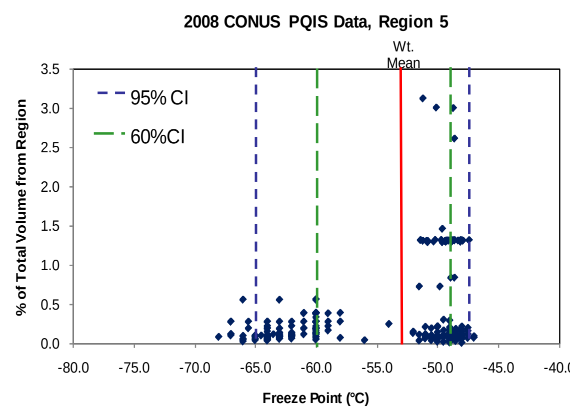

2003 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2004 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2005 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2006 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Freeze Point (ºC)


2007 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

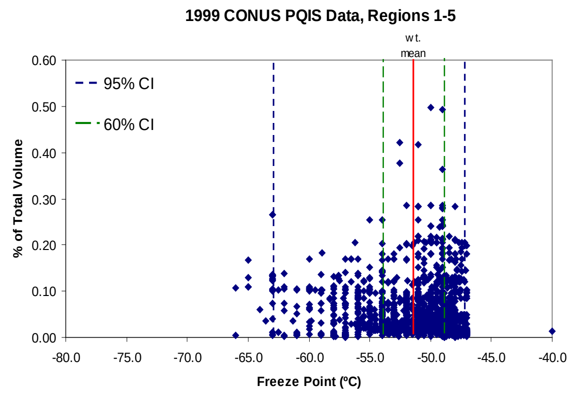

2008 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Freeze Point (ºC)

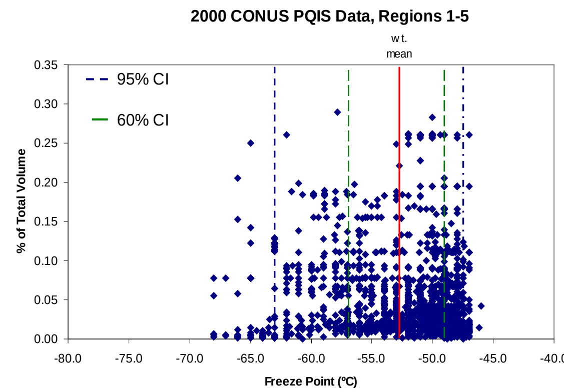
Statistics and Confidence Intervals for the Freeze Point (ºC) of JP-8 Fuel from CONUS Based on PQIS Data from 1999-2008.

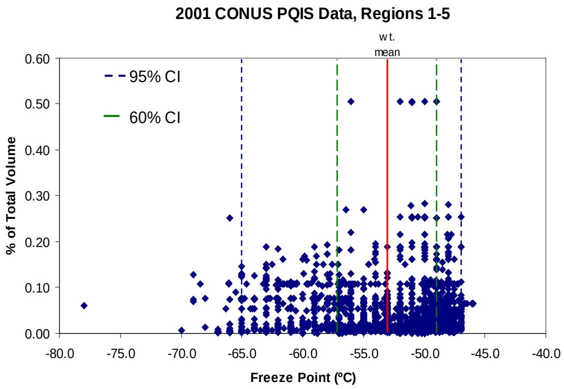
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	-51.5	3.68	(-63.0, -47.2)	(-60.0, -47.5)	(-57.0, -48.0)	(-55.5, -48.4)	(-54.0, -48.9)
2000	-52.7	4.57	(-63.0, -47.5)	(-62.0, -48.0)	(-59.8, -48.2)	(-58.0, -48.8)	(-56.9, -49.0)
2001	-53.0	5.07	(-65.0, -47.0)	(-64.0, -47.7)	(-61.3, -48.0)	(-59.0, -48.2)	(-57.1, -49.0)
2002	-53.0	5.15	(-65.0, -47.0)	(-64.0, -47.7)	(-62.0, -48.0)	(-60.0, -48.4)	(-57.8, -48.9)
2003	-53.3	5.63	(-66.2, -47.5)	(-65.0, -48.0)	(-62.0, -48.1)	(-60.0, -48.7)	(-58.0, -49.0)
2004	-51.6	5.23	(-66.0, -47.2)	(-63.0, -47.9)	(-58.0, -48.0)	(-55.7, -48.0)	(-54.0, -48.4)
2005	-52.0	4.45	(-65.0, -47.0)	(-61.0, -47.6)	(-59.0, -48.0)	(-57.0, -48.0)	(-55.0, -48.6)
2006	-52.2	4.14	(-63.0, -47.7)	(-60.9, -48.0)	(-58.1, -48.3)	(-56.5, -48.5)	(-55.2, -48.9)
2007	-52.9	4.33	(-62.0, -47.4)	(-60.0, -47.9)	(-59.8, -48.3)	(-58.0, -48.9)	(-56.0, -49.3)
2008	-51.8	4.80	(-62.0, -47.4)	(-60.0, -47.7)	(-58.5, -48.1)	(-56.0, -48.3)	(-54.7, -48.6)

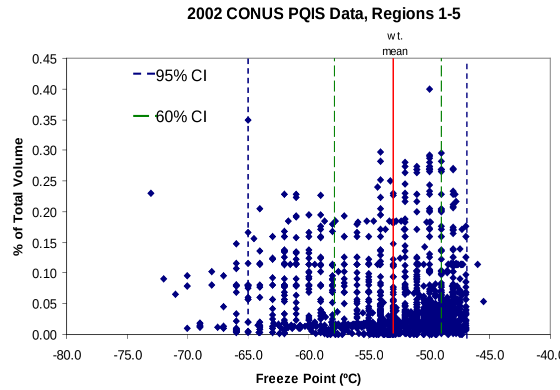
Statistics and Confidence Intervals for the Freeze Point(ºC) of JP-8 Fuel from CONUS Based on the Smallest Extreme Value Distribution of PQIS Data from 1999-2008.

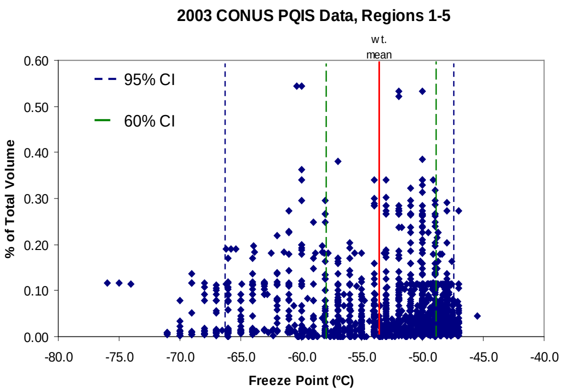
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	3.70	(-60.5, -46.1)	(-58.5, -46.7)	(-56.4, -47.5)	(-55.1, -48.0)	(-54.2, -48.5)	0.980
2000	4.41	(-63.3, -46.2)	(-60.9, -46.9)	(-58.4, -47.8)	(-56.9, -48.5)	(-55.9, -49.1)	0.977
2001	4.99	(-65.1, -45.7)	(-62.3, -46.5)	(-59.5, -47.5)	(-57.9, -48.3)	(-56.6, -48.9)	0.977
2002	5.17	(-65.5, -45.4)	(-62.6, -46.2)	(-59.7, -47.3)	(-58.0, -48.0)	(-56.7, -48.7)	0.978
2003	5.35	(-66.2, -45.4)	(-63.3, -46.3)	(-60.3, -47.4)	(-58.5, -48.2)	(-57.1, -48.9)	0.975
2004	4.68	(-62.9, -44.8)	(-60.4, -45.5)	(-57.7, -46.5)	(-56.1, -47.2)	(-55.0, -47.8)	0.956
2005	4.42	(-62.7, -45.5)	(-60.3, -46.2)	(-57.8, -47.1)	(-56.3, -47.8)	(-55.2, -48.4)	0.979
2006	4.30	(-62.6, -45.9)	(-60.2, -46.6)	(-57.8, -47.5)	(-56.4, -48.1)	(-55.3, -48.7)	0.983
2007	4.09	(-62.8, -46.9)	(-60.5, -47.5)	(-58.2, -48.4)	(-56.8, -49.0)	(-55.8, -49.5)	0.990
2008	3.99	(-61.5, -46.0)	(-59.3, -46.6)	(-57.0, -47.4)	(-55.7, -48.0)	(-54.7, -48.6)	0.979

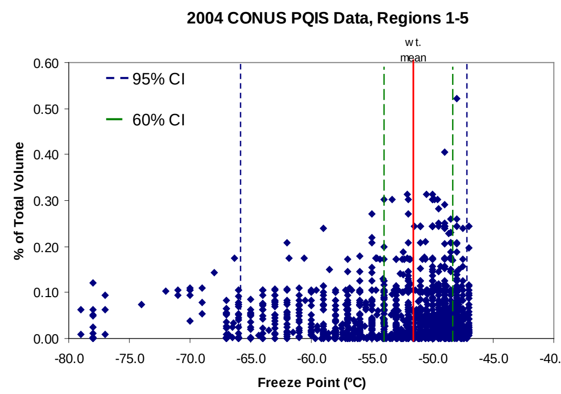


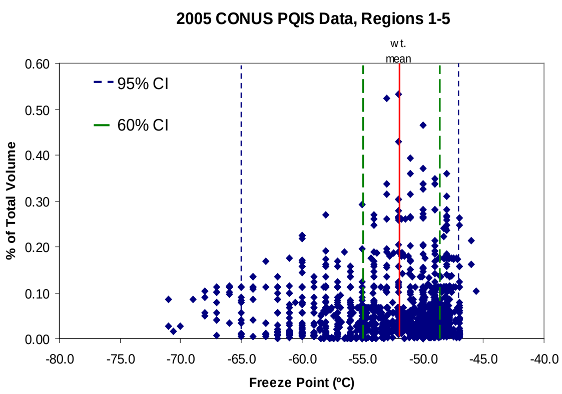


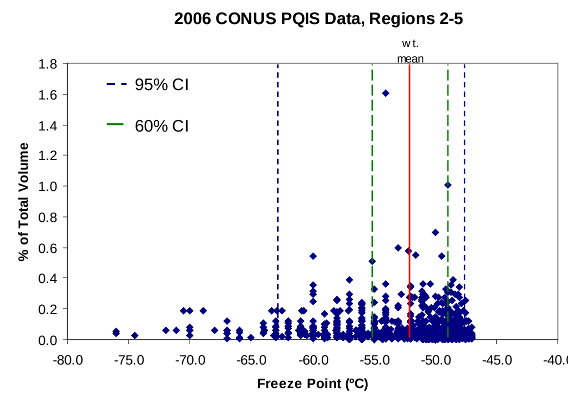

2001 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Freeze Point (ºC)

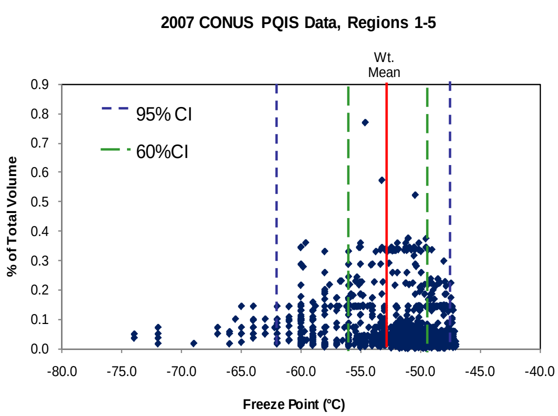

2002 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Freeze Point (ºC)

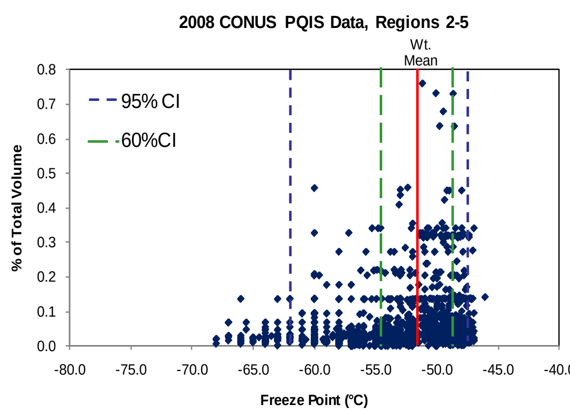

2003 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Freeze Point (ºC)


2004 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Freeze Point (ºC)


2005 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Freeze Point (ºC)


2006 CONUS PQIS Data, Regions 2-5
wt. mean
95% CI
60% CI
% of Total Volume
Freeze Point (ºC)


2007 CONUS PQIS Data, Regions 1-5
Wt. Mean
95% CI
60%CI
% of Total Volume
Freeze Point (ºC)


2008 CONUS PQIS Data, Regions 2-5
Wt. Mean
95% CI
60%CI
% of Total Volume
Freeze Point (ºC)

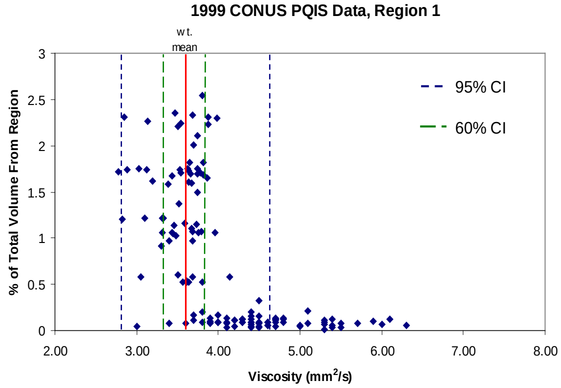
7.4 Viscosity

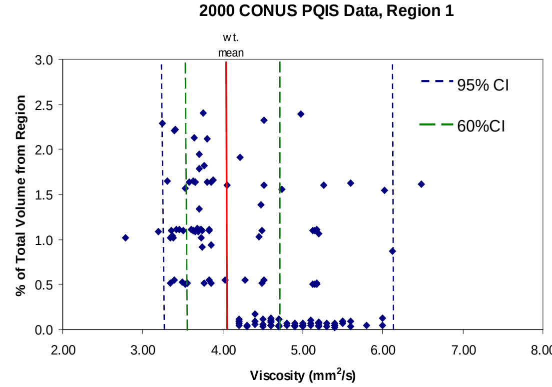
Statistics and Confidence Intervals for the Viscosity (mm²/s) of JP-8 Fuel from Region 1 Based on PQIS Data from 1999-2007.

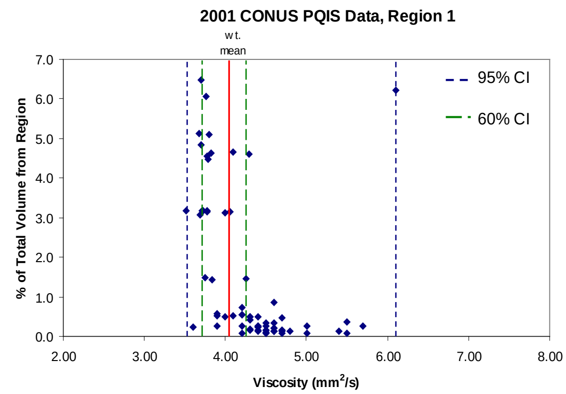
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	3.60	0.872	(2.83, 4.60)	(2.85, 4.20)	(3.10, 3.96)	(3.20, 3.86)	(3.33, 3.81)
2000	4.05	0.865	(3.25, 6.12)	(3.31, 5.60)	(3.39, 5.18)	(3.41, 5.10)	(3.53, 4.70)
2001	4.02	0.606	(3.51, 6.11)	(3.68, 6.11)	(3.69, 4.60)	(3.70, 4.29)	(3.70, 4.26)
2002	4.37	0.614	(3.60, 5.55)	(3.80, 5.40)	(3.90, 5.12)	(4.00, 5.02)	(4.00, 4.80)
2003	4.75	0.588	(3.99, 5.95)	(4.18, 5.32)	(4.20, 5.30)	(4.22, 5.30)	(4.27, 5.30)
2004	4.81	1.032	(3.00, 6.58)	(3.09, 6.36)	(3.63, 6.03)	(4.00, 5.71)	(4.10, 5.64)
2005	4.03	1.012	(3.91, 4.12)	(3.92, 4.12)	(3.92, 4.12)	(4.03, 4.05)	(4.03, 4.03)
2007	4.02	0.089	(3.82, 4.07)	(3.82, 4.07)	(4.01, 4.07)	(4.01, 4.07)	(4.01, 4.07)

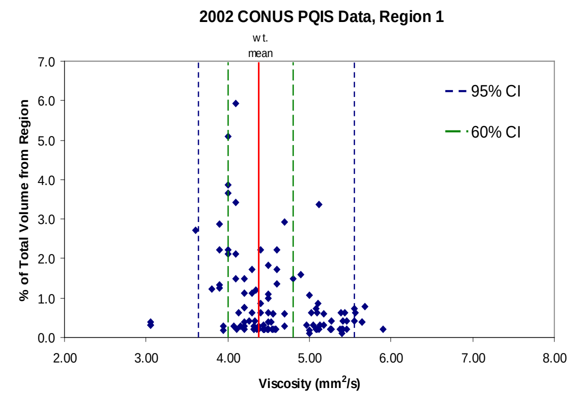
Statistics and Confidence Intervals for the Viscosity (mm²/s) of JP-8 Fuel from Region 1 Based on the Loglogistic Distribution of PQIS Data from 1999-2007.

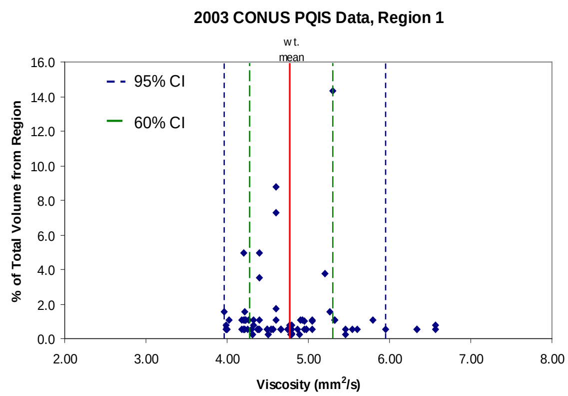
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.394	(2.90, 4.48)	(3.02, 4.28)	(3.15, 4.08)	(3.23, 3.97)	(3.29, 3.88)	0.972
2000	0.769	(3.09, 5.90)	(3.20, 5.36)	(3.33, 4.89)	(3.43, 4.64)	(3.51, 4.47)	0.965
2001	0.703	(3.56, 5.31)	(3.59, 4.84)	(3.63, 4.48)	(3.67, 4.30)	(3.70, 4.19)	0.947
2002	0.488	(3.53, 5.47)	(3.67, 5.21)	(3.82, 4.96)	(3.91, 4.82)	(3.99, 4.71)	0.971
2003	0.586	(4.03, 6.16)	(4.11, 5.74)	(4.21, 5.39)	(4.28, 5.20)	(4.34, 5.06)	0.974
2004	0.969	(2.79, 6.71)	(3.17, 6.32)	(3.56, 5.91)	(3.81, 5.66)	(3.99, 5.47)	0.983
2005	0.069	(3.91, 4.19)	(3.93, 4.15)	(3.95, 4.12)	(3.97, 4.10)	(3.98, 4.08)	0.769
2007	0.041	(3.94, 4.11)	(3.96, 4.09)	(3.97, 4.07)	(3.98, 4.06)	(3.99, 4.05)	0.742

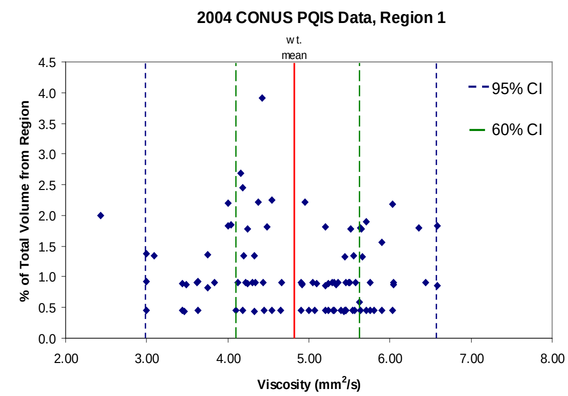


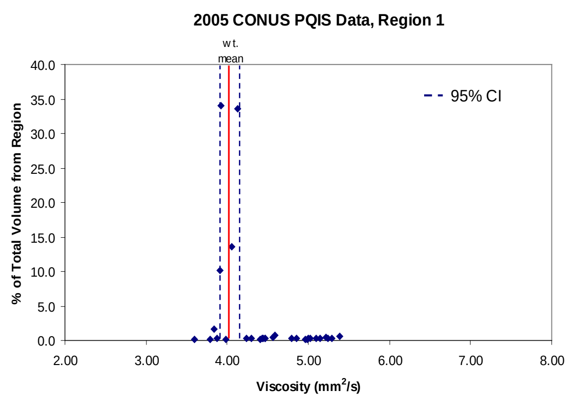


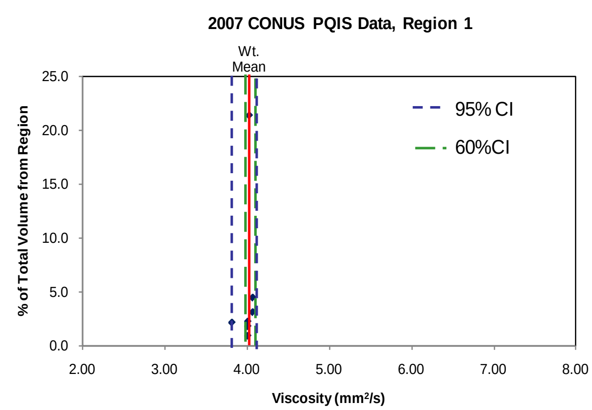

2001 CONUS PQIS Data, Region 1
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2002 CONUS PQIS Data, Region 1
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2003 CONUS PQIS Data, Region 1
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2004 CONUS PQIS Data, Region 1
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2005 CONUS PQIS Data, Region 1
wt.
mean
95% CI
% of Total Volume from Region
Viscosity (mm²/s)

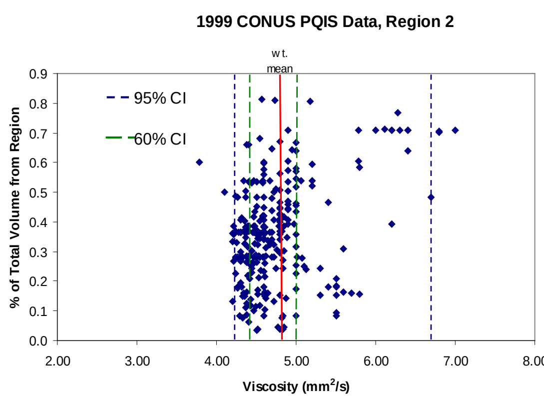

2007 CONUS PQIS Data, Region 1
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)

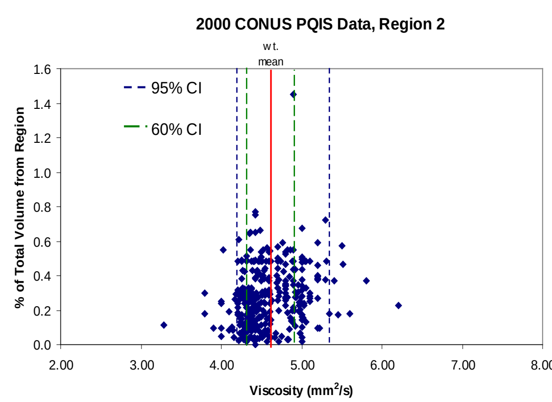
Statistics and Confidence Intervals for the Viscosity (mm²/s) of JP-8 Fuel from Region 2 Based on PQIS Data from 1999-2008.

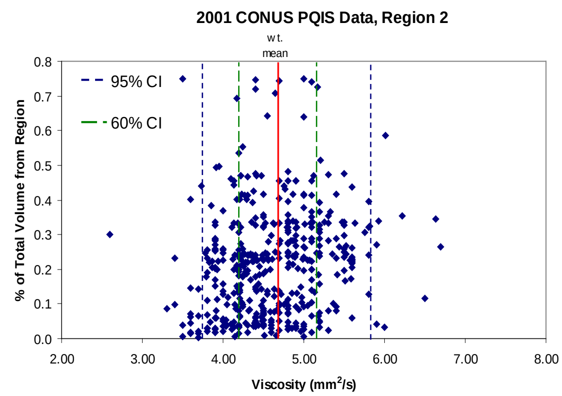
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	4.82	0.518	(4.21, 6.70)	(4.25, 6.30)	(4.32, 5.80)	(4.37, 5.20)	(4.40, 5.00)
2000	4.61	0.342	(4.17, 5.34)	(4.22, 5.20)	(4.27, 5.05)	(4.31, 5.00)	(4.33, 4.90)
2001	4.68	0.583	(3.73, 5.82)	(3.87, 5.60)	(3.94, 5.50)	(4.14, 5.30)	(4.20, 5.17)
2002	4.91	0.710	(3.80, 6.15)	(3.88, 5.94)	(4.20, 5.70)	(4.34, 5.57)	(4.50, 5.40)
2003	5.00	0.491	(3.87, 5.70)	(4.04, 5.52)	(4.33, 5.43)	(4.56, 5.39)	(4.63, 5.38)
2004	5.09	0.666	(4.02, 5.92)	(4.10, 5.68)	(4.25, 5.58)	(4.45, 5.50)	(4.60, 5.44)
2005	4.92	0.550	(4.08, 6.37)	(4.11, 5.90)	(4.31, 5.38)	(4.36, 5.30)	(4.47, 5.22)
2006	4.73	0.406	(4.00, 5.72)	(4.10, 5.28)	(4.26, 5.15)	(4.40, 5.07)	(4.46, 5.00)
2007	4.54	0.394	(3.30, 5.16)	(4.00, 5.08)	(4.20, 4.91)	(4.28, 4.86)	(4.28, 4.80)
2008	4.64	2.518	(3.96, 5.59)	(4.06, 5.51)	(4.13, 5.38)	(4.21, 5.28)	(4.25, 5.08)

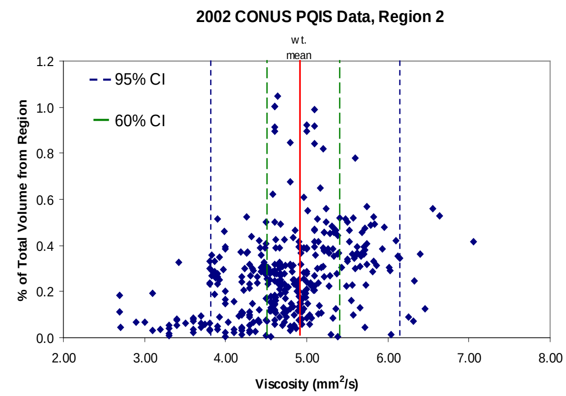
Statistics and Confidence Intervals for the Viscosity (mm²/s) of JP-8 Fuel from Region 2 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

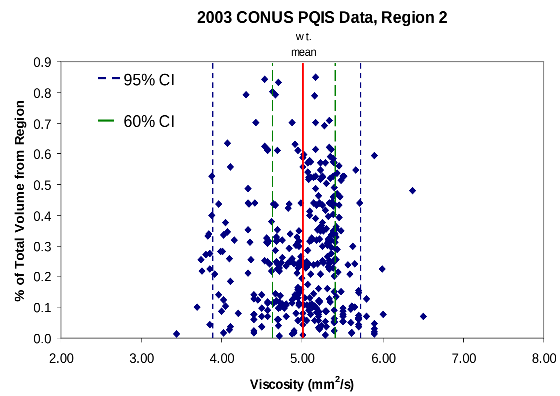
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.565	(4.09, 6.18)	(4.18, 5.79)	(4.28, 5.45)	(4.36, 5.26)	(4.42, 5.13)	0.967
2000	0.330	(4.02, 5.35)	(4.12, 5.18)	(4.23, 5.02)	(4.30, 4.92)	(4.36, 4.85)	0.980
2001	0.579	(3.58, 5.92)	(3.78, 5.65)	(3.99, 5.39)	(4.13, 5.23)	(4.23, 5.11)	0.992
2002	0.623	(3.68, 6.19)	(3.91, 5.93)	(4.16, 5.67)	(4.32, 5.51)	(4.43, 5.38)	0.996
2003	0.447	(4.10, 5.91)	(4.28, 5.73)	(4.46, 5.54)	(4.58, 5.43)	(4.66, 5.34)	0.969
2004	0.544	(4.07, 6.26)	(4.25, 6.01)	(4.45, 5.76)	(4.58, 5.61)	(4.67, 5.50)	0.961
2005	0.500	(4.08, 6.06)	(4.21, 5.79)	(4.36, 5.53)	(4.46, 5.38)	(4.53, 5.27)	0.985
2006	0.371	(4.03, 5.53)	(4.16, 5.36)	(4.29, 5.19)	(4.38, 5.09)	(4.45, 5.01)	0.990
2007	0.401	(3.73, 5.36)	(3.89, 5.20)	(4.06, 5.03)	(4.16, 4.93)	(4.24, 4.85)	0.948
2008	0.479	(3.68, 5.62)	(3.87, 5.42)	(4.06, 5.22)	(4.18, 5.10)	(4.28, 5.01)	0.969

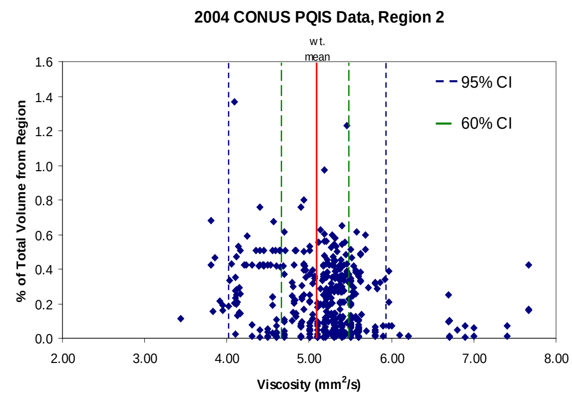


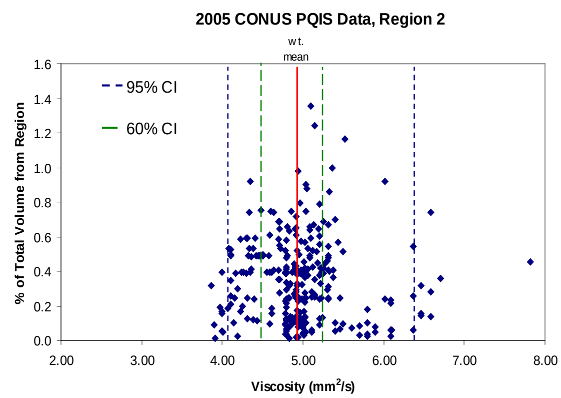


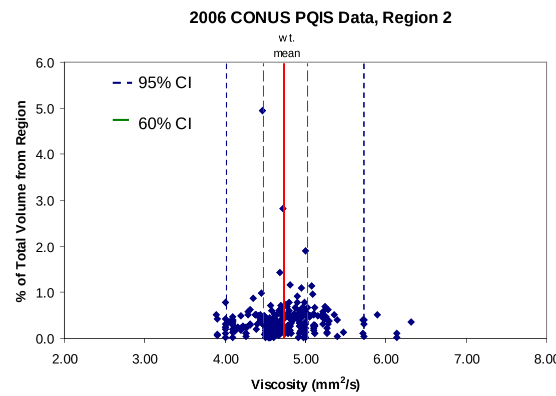

2001 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)

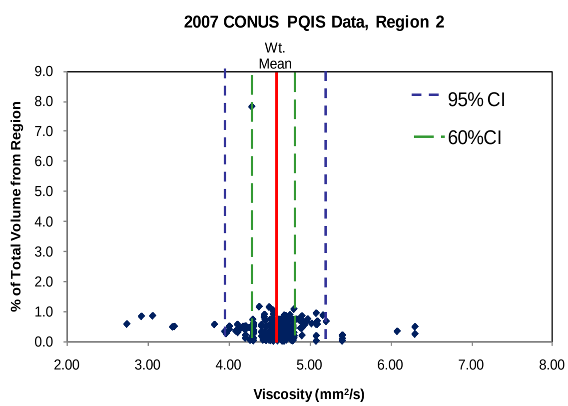

2002 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)

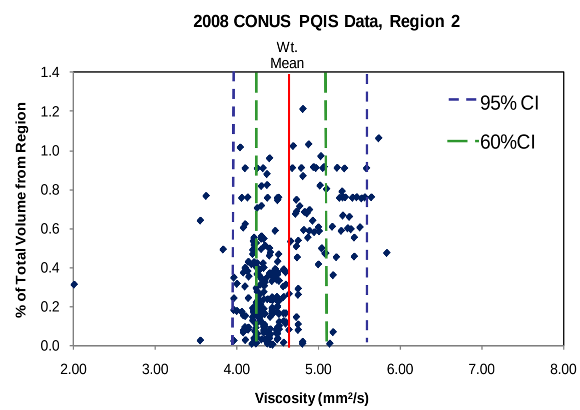

2003 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2004 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2005 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2006 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2007 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)

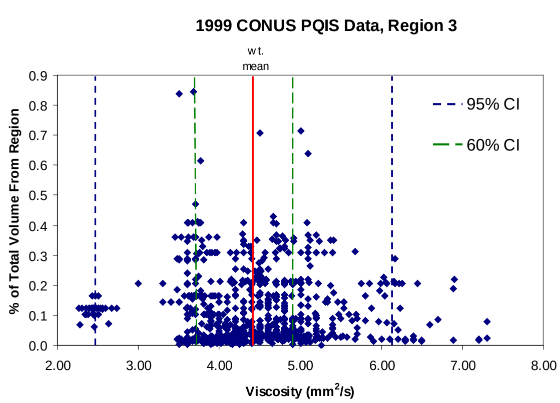

2008 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)

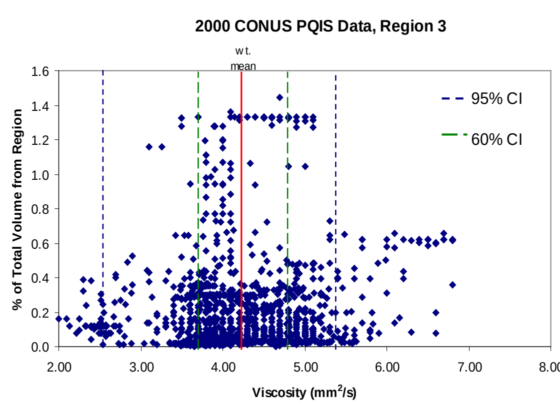
Statistics and Confidence Intervals for the Viscosity (mm²/s) of JP-8 Fuel from Region 3 Based on PQIS Data from 1999-2008.

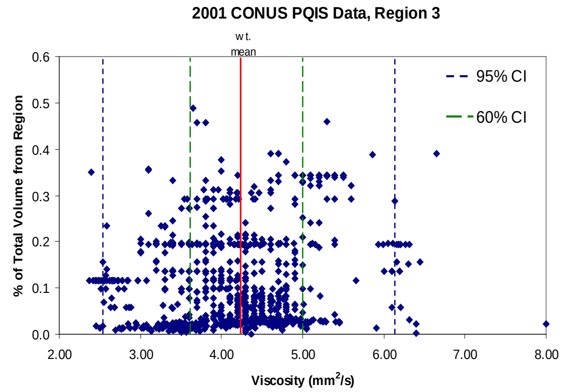
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	4.36	0.757	(2.48, 6.10)	(3.45, 5.68)	(3.60, 5.20)	(3.67, 5.10)	(3.70, 4.92)
2000	4.19	0.691	(2.51, 5.38)	(2.73, 5.20)	(3.50, 4.94)	(3.60, 4.87)	(3.70, 4.79)
2001	4.25	0.786	(2.58, 6.13)	(2.87, 5.60)	(3.30, 5.30)	(3.40, 5.12)	(3.60, 5.00)
2002	4.39	0.830	(2.50, 6.20)	(3.00, 5.60)	(3.20, 5.40)	(3.40, 5.20)	(3.60, 5.10)
2003	4.56	0.966	(2.70, 6.25)	(3.10, 6.00)	(3.30, 5.50)	(3.50, 5.30)	(3.80, 5.20)
2004	4.42	0.904	(3.19, 6.35)	(3.33, 6.17)	(3.83, 5.68)	(3.86, 5.30)	(3.89, 4.90)
2005	4.49	0.855	(3.28, 5.91)	(3.31, 5.70)	(3.50, 5.50)	(3.70, 5.30)	(3.80, 5.18)
2006	4.55	0.824	(3.26, 5.83)	(3.40, 5.64)	(3.60, 5.40)	(3.79, 5.20)	(3.80, 5.10)
2007	4.56	0.782	(3.46, 6.16)	(3.58, 5.61)	(3.72, 5.40)	(3.84, 5.10)	(3.90, 5.01)
2008	4.48	0.722	(3.31, 5.64)	(3.48, 5.39)	(3.73, 5.10)	(3.90, 5.01)	(4.00, 5.00)

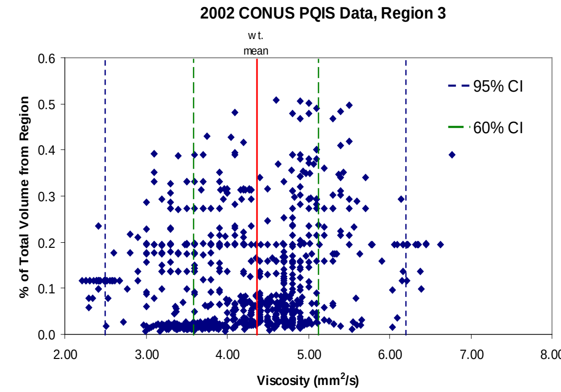
Statistics and Confidence Intervals for the Viscosity(mm²/s) of JP-8 Fuel from Region 3 Based on the Normal Distribution of PQIS Data from 1999-2008.

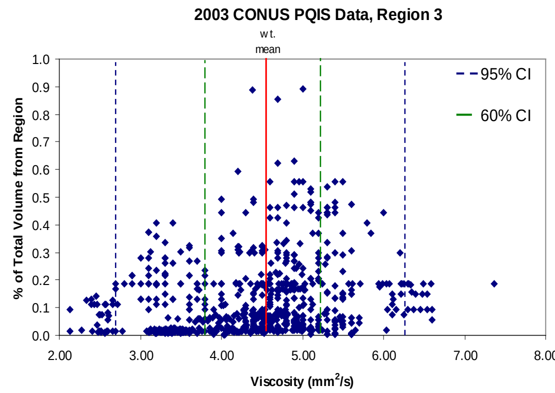
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.764	(2.87, 5.86)	(3.11, 5.62)	(3.39, 5.34)	(3.57, 5.16)	(3.72, 5.01)	0.986
2000	0.666	(2.89, 5.50)	(3.10, 5.29)	(3.34, 5.05)	(3.50, 4.88)	(3.63, 4.75)	0.986
2001	0.828	(2.62, 5.87)	(2.89, 5.61)	(3.19, 5.31)	(3.39, 5.11)	(3.55, 4.94)	0.996
2002	0.863	(2.70, 6.08)	(2.97, 5.81)	(3.29, 5.50)	(3.50, 5.29)	(3.67, 5.12)	0.993
2003	0.852	(2.90, 6.23)	(3.16, 5.97)	(3.47, 5.66)	(3.68, 5.45)	(3.85, 5.28)	0.986
2004	0.823	(2.80, 6.03)	(3.06, 5.77)	(3.36, 5.47)	(3.56, 5.27)	(3.72, 5.11)	0.955
2005	0.740	(3.04, 5.94)	(3.28, 5.71)	(3.54, 5.44)	(3.73, 5.26)	(3.87, 5.12)	0.988
2006	0.678	(3.22, 5.88)	(3.43, 5.66)	(3.68, 5.42)	(3.85, 5.25)	(3.98, 5.12)	0.992
2007	0.669	(3.25, 5.87)	(3.46, 5.66)	(3.71, 5.42)	(3.87, 5.26)	(4.00, 5.13)	0.979
2008	0.599	(3.61, 5.96)	(3.80, 5.77)	(4.02, 5.55)	(4.16, 5.41)	(4.28, 5.29)	0.987

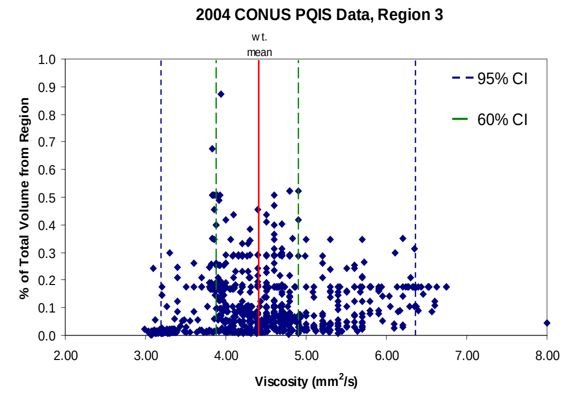


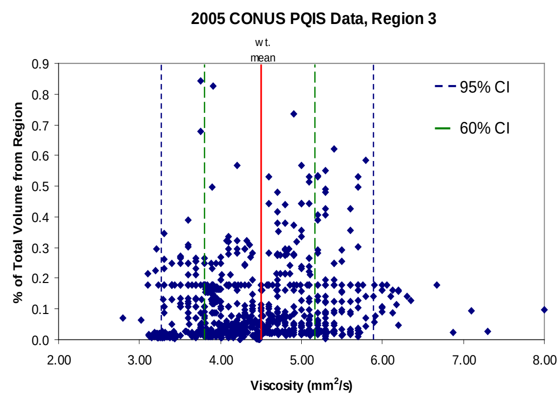


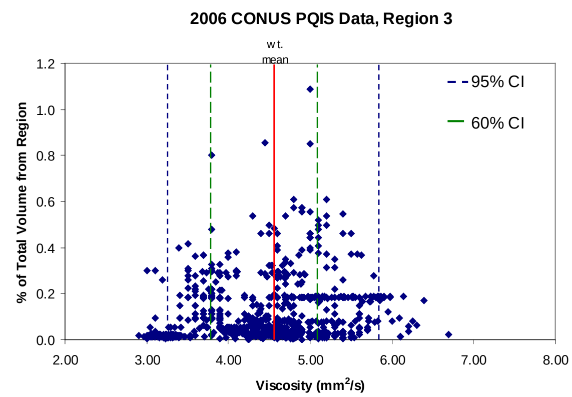

2001 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.1 0.2 0.3 0.4 0.5 0.6
2.00 3.00 4.00 5.00 6.00 7.00 8.00

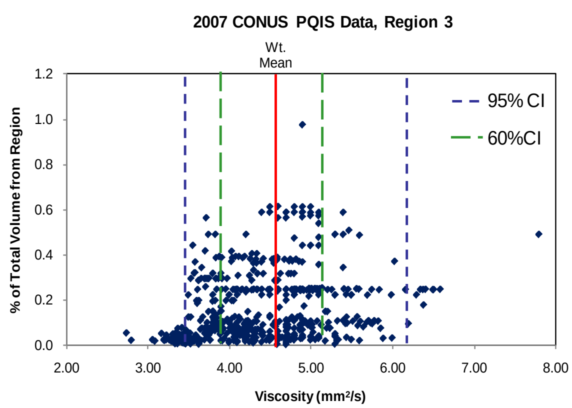

2002 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.1 0.2 0.3 0.4 0.5 0.6
2.00 3.00 4.00 5.00 6.00 7.00 8.00

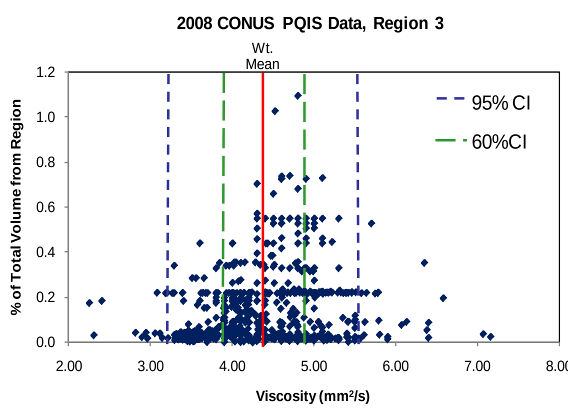

2003 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
2.00 3.00 4.00 5.00 6.00 7.00 8.00


2004 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
2.00 3.00 4.00 5.00 6.00 7.00 8.00


2005 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
2.00 3.00 4.00 5.00 6.00 7.00 8.00


2006 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.2 0.4 0.6 0.8 1.0 1.2
2.00 3.00 4.00 5.00 6.00 7.00 8.00


2007 CONUS PQIS Data, Region 3
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.2 0.4 0.6 0.8 1.0 1.2
2.00 3.00 4.00 5.00 6.00 7.00 8.00

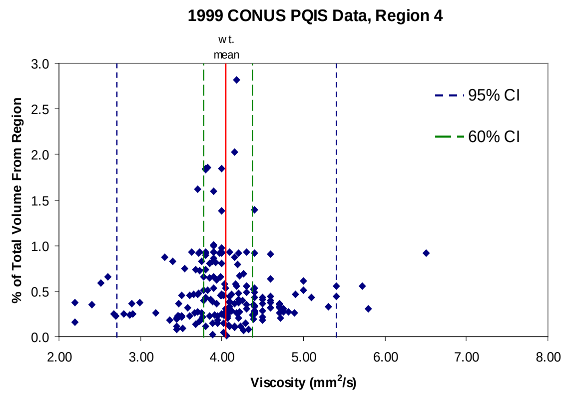

2008 CONUS PQIS Data, Region 3
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)
0.0 0.2 0.4 0.6 0.8 1.0 1.2
2.00 3.00 4.00 5.00 6.00 7.00 8.00

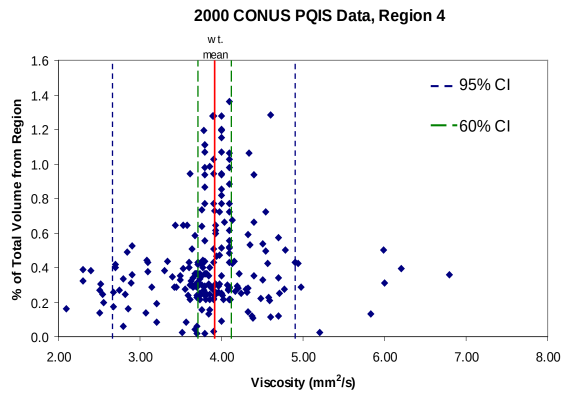
Statistics and Confidence Intervals for the Viscosity (mm^2/s) of JP-8 Fuel from Region 4 Based on PQIS Data from 1999-2008.

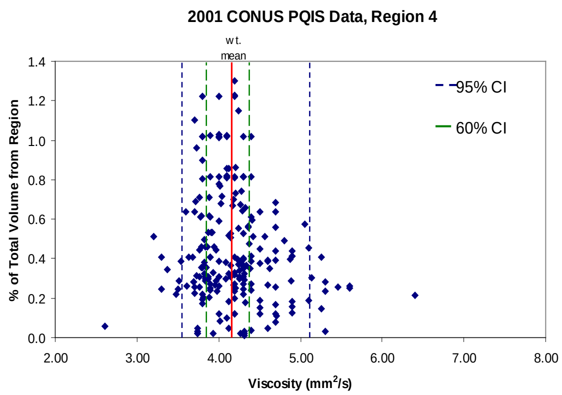
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	4.04	0.339	(2.70, 5.40)	(3.30, 4.90)	(3.60, 4.60)	(3.70, 4.40)	(3.78, 4.37)
2000	3.91	0.634	(2.67, 4.90)	(2.85, 4.70)	(3.43, 4.48)	(3.61, 4.31)	(3.70, 4.10)
2001	4.15	0.464	(3.54, 5.10)	(3.69, 4.90)	(3.77, 4.70)	(3.80, 4.40)	(3.83, 4.36)
2002	4.54	0.910	(3.66, 6.80)	(3.72, 6.40)	(3.79, 5.80)	(3.84, 5.40)	(3.92, 5.15)
2003	4.16	0.562	(3.01, 5.50)	(3.70, 5.14)	(3.80, 4.85)	(3.80, 4.60)	(3.90, 4.42)
2004	4.28	0.700	(3.70, 5.90)	(3.70, 5.45)	(3.80, 4.96)	(3.86, 4.72)	(3.90, 4.66)
2005	4.36	0.553	(3.60, 5.59)	(3.79, 5.30)	(3.80, 4.93)	(3.80, 4.85)	(3.90, 4.80)
2006	4.38	0.931	(2.98, 6.40)	(3.29, 6.18)	(3.66, 5.83)	(3.70, 5.19)	(3.80, 4.97)
2007	4.83	1.204	(2.76, 7.75)	(3.07, 7.29)	(3.70, 7.00)	(3.80, 6.47)	(3.80, 6.00)
2008	4.39	0.592	(3.55, 5.44)	(3.80, 5.27)	(3.86, 5.04)	(3.90, 4.92)	(3.90, 4.87)

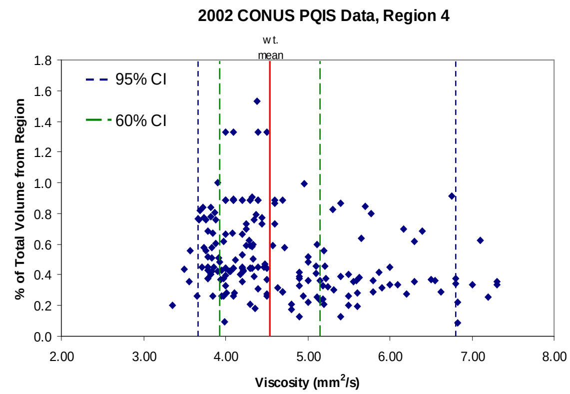
Statistics and Confidence Intervals for the Viscosity (mm^2/s) of JP-8 Fuel from Region 4 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

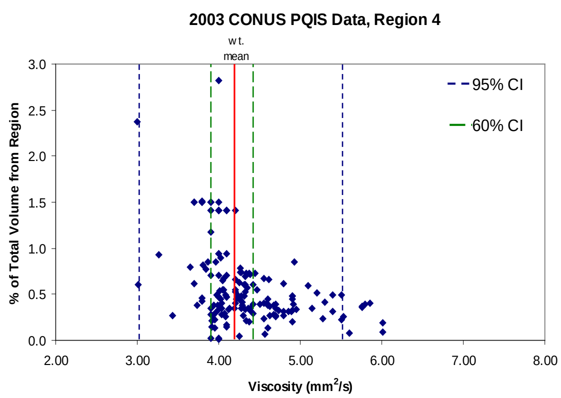
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.520	(3.04, 5.14)	(3.22, 4.91)	(3.42, 4.68)	(3.54, 4.53)	(3.64, 4.43)	0.968
2000	0.515	(2.92, 5.00)	(3.11, 4.77)	(3.30, 4.54)	(3.42, 4.40)	(3.52, 4.30)	0.955
2001	0.374	(3.49, 4.99)	(3.60, 4.80)	(3.72, 4.61)	(3.80, 4.50)	(3.86, 4.42)	0.990
2002	1.008	(3.60, 6.80)	(3.68, 6.05)	(3.79, 5.45)	(3.88, 5.14)	(3.95, 4.94)	0.983
2003	0.463	(3.33, 5.18)	(3.47, 4.96)	(3.62, 4.73)	(3.73, 4.60)	(3.80, 4.50)	0.968
2004	0.635	(3.65, 5.73)	(3.71, 5.26)	(3.78, 4.87)	(3.84, 4.67)	(3.89, 4.54)	0.988
2005	0.525	(3.55, 5.60)	(3.67, 5.28)	(3.80, 4.98)	(3.89, 4.82)	(3.96, 4.70)	0.980
2006	0.851	(2.99, 6.34)	(3.20, 5.86)	(3.44, 5.40)	(3.59, 5.14)	(3.72, 4.95)	0.969
2007	1.341	(2.90, 8.02)	(3.15, 7.16)	(3.45, 6.38)	(3.66, 5.94)	(3.83, 5.64)	0.970
2008	0.521	(3.46, 5.54)	(3.61, 5.28)	(3.78, 5.02)	(3.89, 4.87)	(3.98, 4.76)	0.974

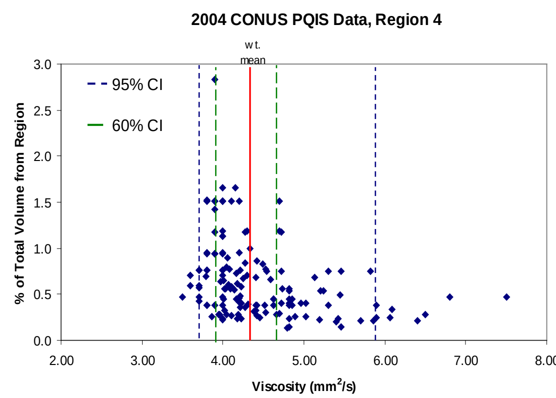


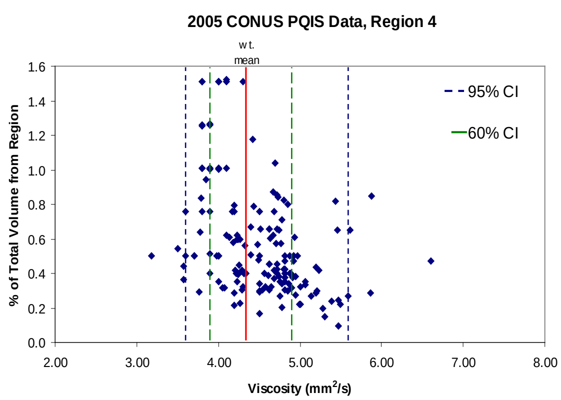


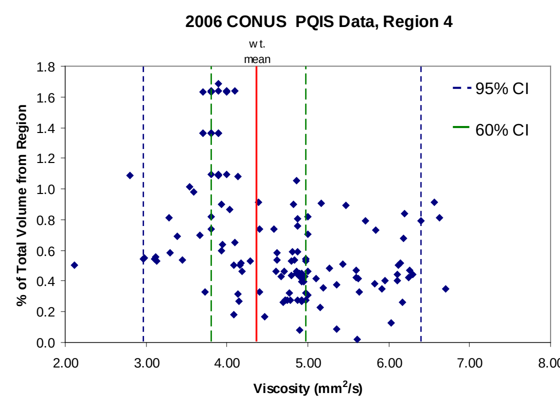

2001 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00

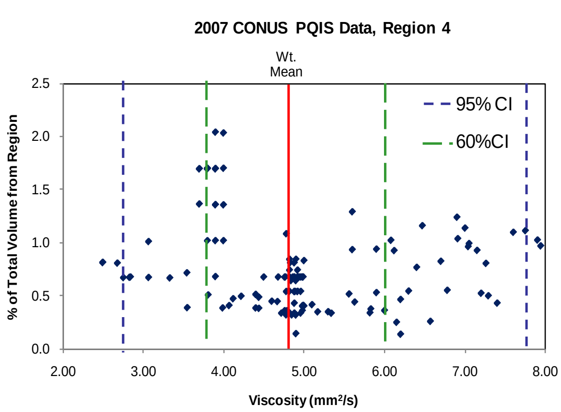

2002 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00

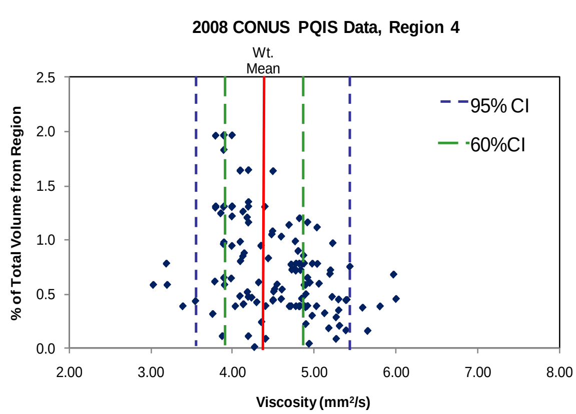

2003 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00


2004 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00


2005 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00


2006 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00


2007 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)
2.5
2.0
1.5
1.0
0.5
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00

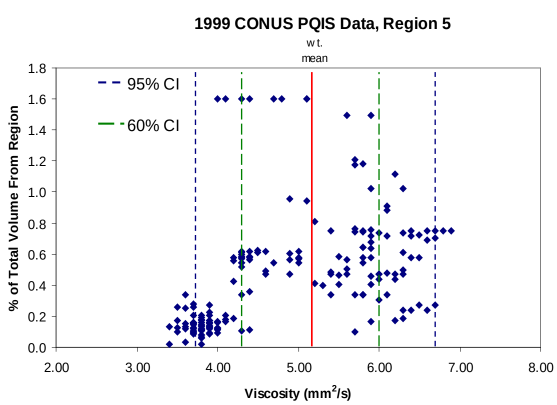

2008 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)
2.5
2.0
1.5
1.0
0.5
0.0
2.00
3.00
4.00
5.00
6.00
7.00
8.00

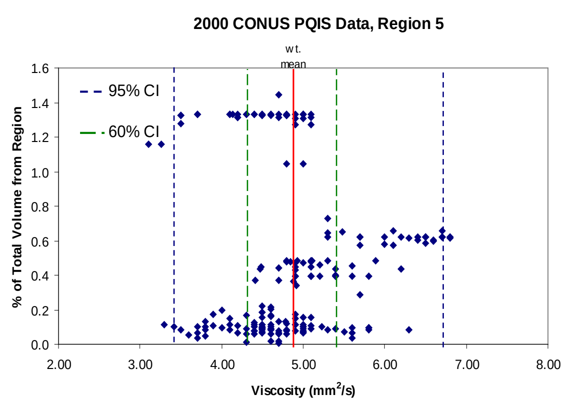
Statistics and Confidence Intervals for the Viscosity (mm^2/s) of JP-8 Fuel from Region 5 Based on PQIS Data from 1999-2008.

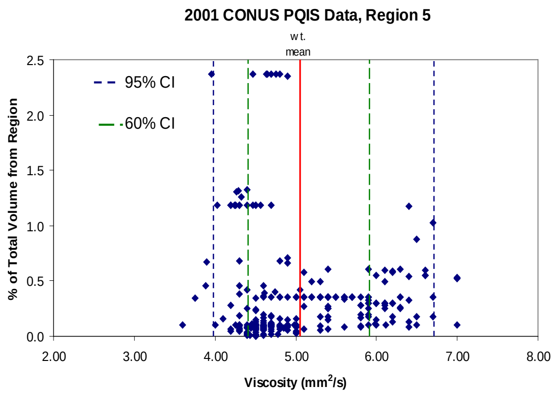
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	5.19	1.070	(3.70, 6.70)	(3.80, 6.50)	(4.00, 6.30)	(4.20, 6.20)	(4.30, 6.00)
2000	4.88	0.776	(3.42, 6.70)	(3.50, 6.60)	(3.90, 6.30)	(4.14, 5.70)	(4.30, 5.40)
2001	5.04	0.728	(3.96, 6.70)	(4.20, 6.50)	(4.25, 6.30)	(4.30, 6.10)	(4.40, 5.90)
2002	5.04	0.670	(4.10, 6.40)	(4.27, 6.33)	(4.34, 6.19)	(4.40, 6.00)	(4.42, 5.88)
2003	5.19	0.755	(3.94, 6.73)	(4.17, 6.60)	(4.29, 6.33)	(4.38, 6.20)	(4.45, 6.07)
2004	5.38	0.696	(4.32, 6.70)	(4.40, 6.60)	(4.52, 6.40)	(4.60, 6.20)	(4.70, 6.09)
2005	4.77	0.668	(3.80, 6.20)	(3.90, 6.10)	(4.09, 5.72)	(4.13, 5.54)	(4.22, 5.40)
2006	4.69	0.657	(4.00, 6.70)	(4.10, 6.40)	(4.12, 5.23)	(4.20, 5.20)	(4.24, 5.10)
2007	4.39	0.298	(4.00, 4.82)	(4.00, 4.82)	(4.00, 4.78)	(4.10, 4.70)	(4.20, 4.61)
2008	4.54	0.556	(4.00, 5.80)	(4.00, 5.50)	(4.10, 5.20)	(4.19, 4.78)	(4.20, 4.70)

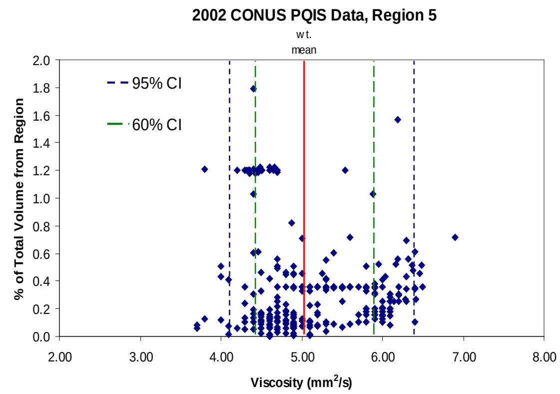
Statistics and Confidence Intervals for the Viscosity (mm^2/s) of JP-8 Fuel from Region 5 Based on the Lognormal Distribution of PQIS Data from 1999-2008.

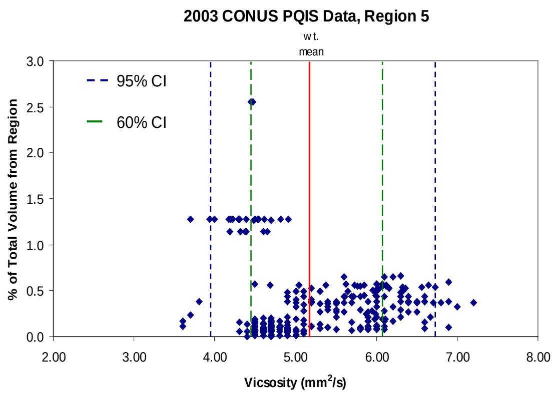
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.854	(3.52, 6.87)	(3.79, 6.59)	(4.09, 6.28)	(4.30, 6.07)	(4.47, 5.90)	0.982
2000	0.806	(3.49, 6.64)	(3.67, 6.30)	(3.90, 5.94)	(4.06, 5.71)	(4.20, 5.53)	0.982
2001	0.811	(3.98, 7.07)	(4.08, 6.57)	(4.20, 6.08)	(4.30, 5.78)	(4.39, 5.58)	0.986
2002	0.727	(4.03, 6.82)	(4.13, 6.41)	(4.26, 5.99)	(4.36, 5.74)	(4.45, 5.56)	0.976
2003	0.855	(3.89, 7.21)	(4.04, 6.77)	(4.22, 6.32)	(4.36, 6.04)	(4.48, 5.84)	0.976
2004	0.703	(4.19, 6.93)	(4.34, 6.64)	(4.54, 6.31)	(4.68, 6.11)	(4.79, 5.95)	0.979
2005	0.637	(3.85, 6.31)	(3.95, 5.96)	(4.07, 5.61)	(4.17, 5.39)	(4.25, 5.23)	0.992
2006	0.546	(4.01, 5.07)	(4.06, 5.72)	(4.14, 5.37)	(4.20, 5.17)	(4.25, 5.03)	0.987
2007	0.265	(3.86, 4.90)	(3.94, 4.82)	(4.04, 4.72)	(4.10, 4.65)	(4.16, 4.60)	0.976
2008	0.429	(3.95, 5.60)	(4.01, 5.35)	(4.08, 5.10)	(4.14, 4.95)	(4.19, 4.84)	0.985

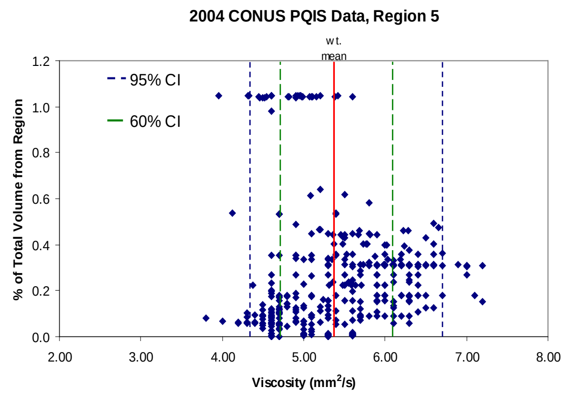


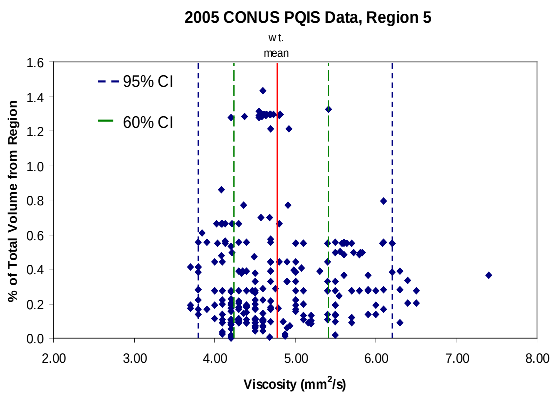


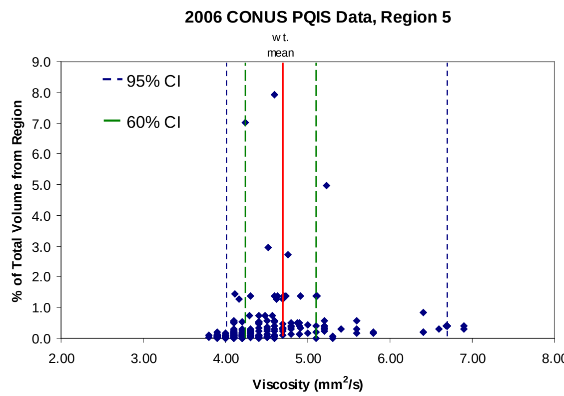

2001 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)

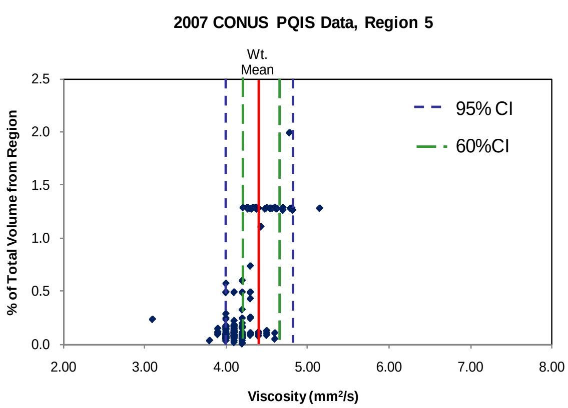

2002 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)

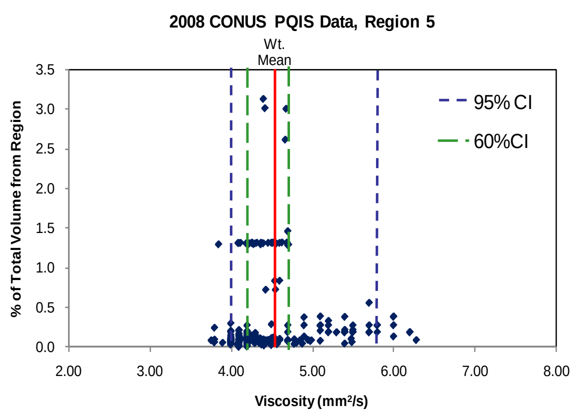

2003 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Vicsosity (mm²/s)


2004 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2005 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2006 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Viscosity (mm²/s)


2007 CONUS PQIS Data, Region 5
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)

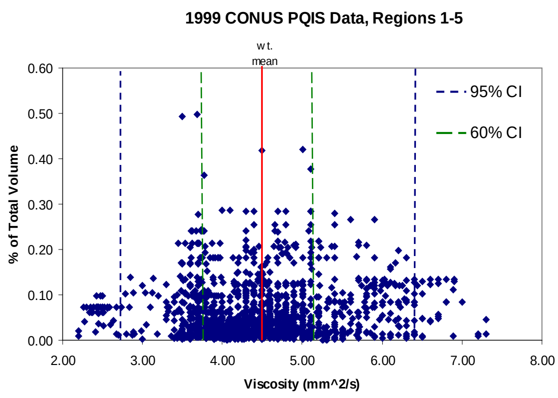

2008 CONUS PQIS Data, Region 5
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Viscosity (mm²/s)

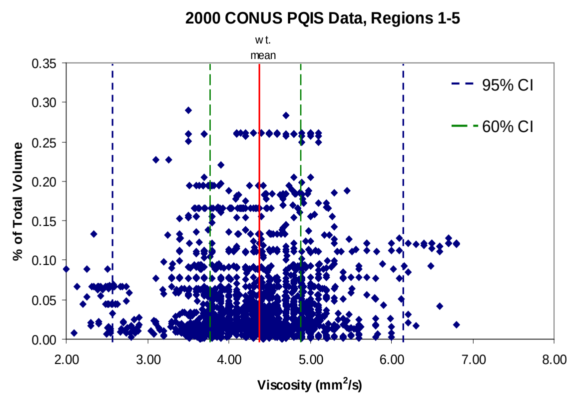
Statistics and Confidence Intervals for the Viscosity (mm²/s) of JP-8 Fuel from CONUS Based on PQIS Data from 1999-2008.

Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	4.50	0.784	(2.73, 6.40)	(3.45, 6.15)	(3.60, 5.78)	(3.70, 5.34)	(3.75, 5.10)
2000	4.36	0.712	(2.59, 6.16)	(3.36, 5.51)	(3.57, 5.11)	(3.69, 5.00)	(3.76, 4.90)
2001	4.48	0.771	(2.78, 6.30)	(3.20, 6.10)	(3.50, 5.50)	(3.70, 5.30)	(3.80, 5.10)
2002	4.61	0.836	(2.90, 6.33)	(3.10, 6.13)	(3.47, 5.68)	(3.71, 5.46)	(3.90, 5.26)
2003	4.74	0.887	(3.00, 6.40)	(3.20, 6.20)	(3.56, 5.84)	(3.90, 5.50)	(4.10, 5.35)
2004	4.72	0.951	(3.26, 6.50)	(3.70, 6.30)	(3.86, 5.94)	(3.91, 5.68)	(3.94, 5.45)
2005	4.59	0.800	(3.30, 6.09)	(3.43, 5.80)	(3.70, 5.50)	(3.80, 5.30)	(3.91, 5.19)
2006	4.59	0.761	(3.32, 5.90)	(3.50, 5.68)	(3.70, 5.36)	(3.80, 5.20)	(4.00, 5.09)
2007	4.54	0.747	(3.48, 6.20)	(3.63, 5.59)	(3.80, 5.17)	(3.90, 5.03)	(4.00, 4.92)
2008	4.50	0.639	(3.40, 5.70)	(3.60, 5.44)	(3.90, 5.16)	(4.00, 5.02)	(4.09, 4.98)

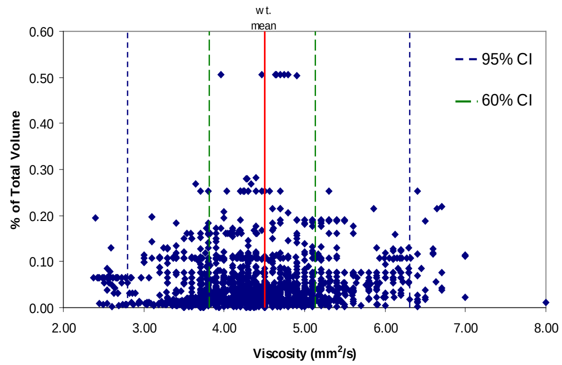
Statistics and Confidence Intervals for the Viscosity (mm²/s) of JP-8 Fuel from CONUS Based on the Lognormal Distribution of PQIS Data from 1999-2008.

Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.841	(2.96, 6.25)	(3.18, 5.94)	(3.45, 5.60)	(3.64, 5.37)	(3.79, 5.20)	0.991
2000	0.727	(2.99, 5.83)	(3.20, 5.59)	(3.44, 5.31)	(3.61, 5.12)	(3.75, 4.97)	0.987
2001	0.829	(2.95, 6.20)	(3.17, 5.90)	(3.44, 5.56)	(3.62, 5.34)	(3.77, 5.16)	0.996
2002	0.854	(2.95, 6.30)	(3.21, 6.02)	(3.52, 5.71)	(3.73, 5.50)	(3.89, 5.33)	0.996
2003	0.849	(3.09, 6.41)	(3.35, 6.14)	(3.65, 5.83)	(3.86, 5.62)	(4.02, 5.45)	0.993
2004	0.874	(3.02, 6.45)	(3.29, 6.17)	(3.61, 5.84)	(3.82, 5.63)	(3.99, 5.46)	0.978
2005	0.710	(3.31, 6.09)	(3.49, 5.82)	(3.71, 5.52)	(3.86, 5.32)	(3.98, 5.17)	0.996
2006	0.649	(3.36, 5.90)	(3.55, 5.68)	(3.77, 5.43)	(3.92, 5.26)	(4.04, 5.13)	0.995
2007	0.632	(3.46, 5.93)	(3.60, 5.66)	(3.77, 5.37)	(3.90, 5.18)	(4.00, 5.04)	0.989
2008	0.562	(3.41, 5.61)	(3.58, 5.43)	(3.79, 5.23)	(3.92, 5.09)	(4.03, 4.98)	0.988

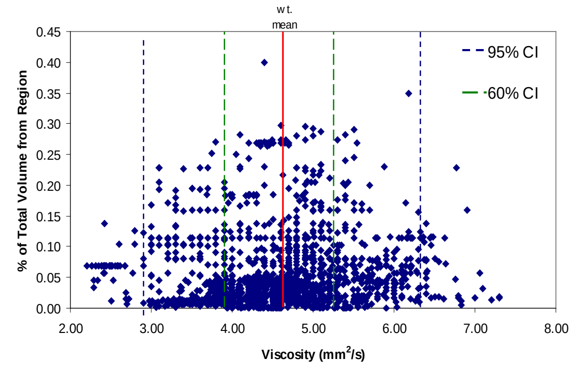




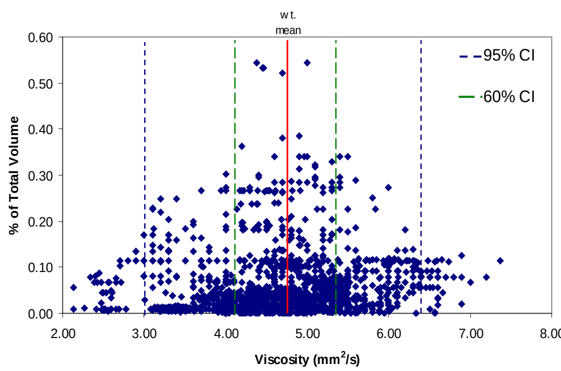
2001 CONUS PQIS Data, Regions 1-5



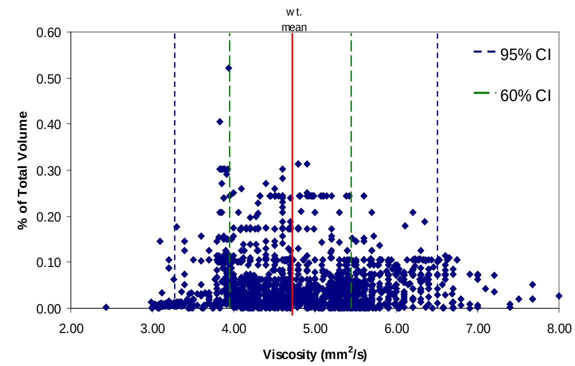
2002 CONUS PQIS Data, Regions 1-5



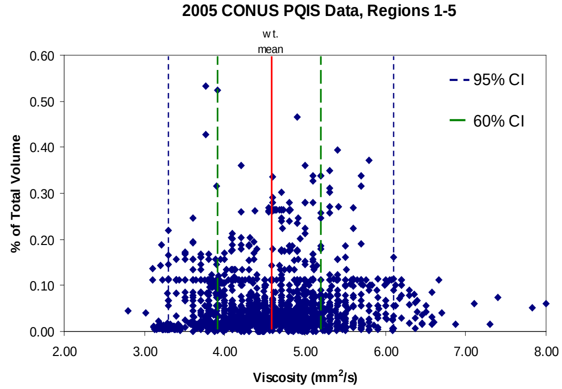
2003 CONUS PQiS Data, Regions 1-5



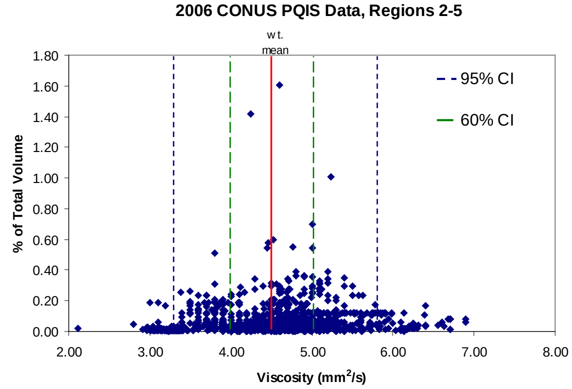
2004 CONUS PQIS Data, Regions 1-5



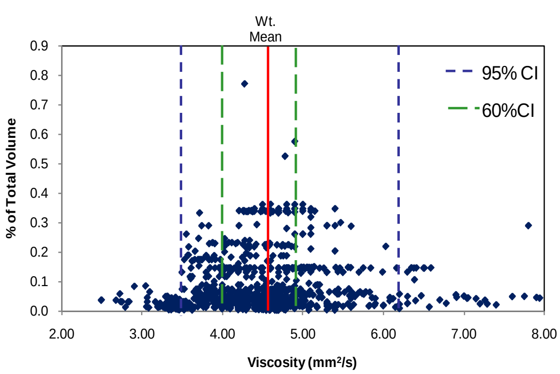
2005 CONUS PQIS Data, Regions 1-5



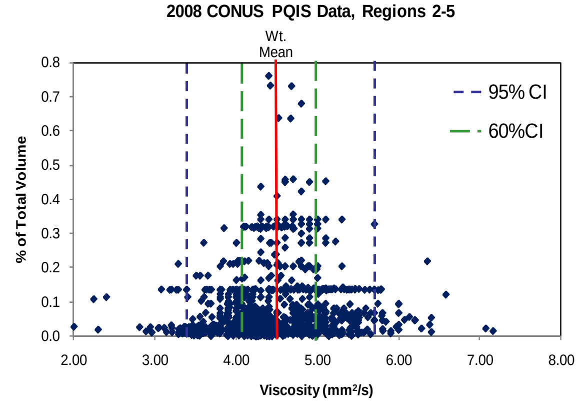
2006 CONUS PQIS Data, Regions 2-5



2007 CONUS PQIS Data, Regions 1-5



2008 CONUS PQIS Data, Regions 2-5



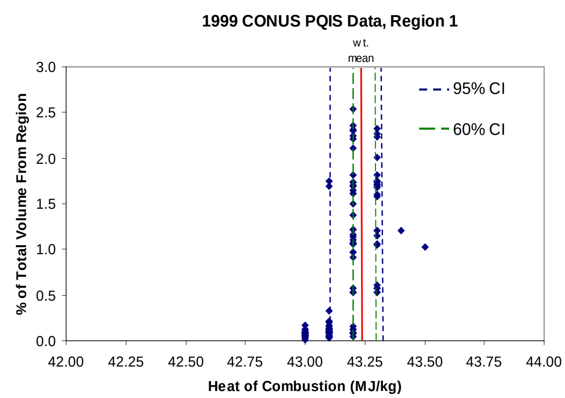
7.5 Heat of Combustion (by mass)

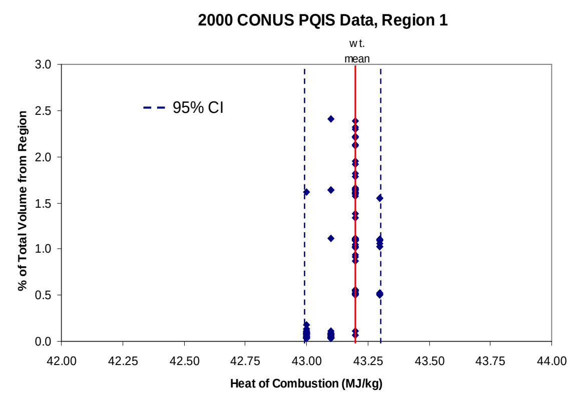
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 1 Based on PQIS Data from 1999-2007.

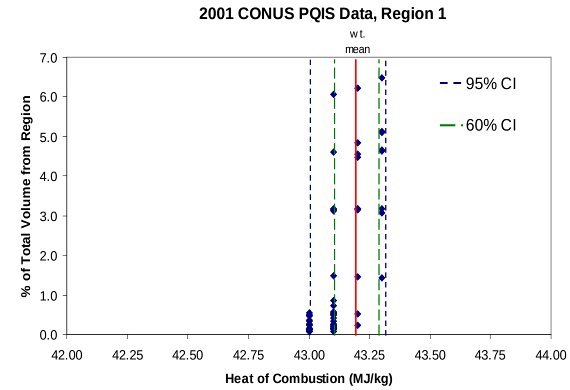
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	43.23	0.133	(43.10, 43.30)	(43.10, 43.30)	(43.20, 43.30)	(43.20, 43.30)	(43.20, 43.30)
2000	43.20	0.115	(43.00, 43.30)	(43.10, 43.30)	(43.10, 43.30)	(43.20, 43.30)	(43.20, 43.20)
2001	43.19	0.135	(43.00, 43.30)	(43.00, 43.30)	(43.10, 43.30)	(43.10, 43.30)	(43.10, 43.30)
2002	43.05	0.110	(43.00, 43.15)	(43.00, 43.12)	(43.00, 43.10)	(43.00, 43.10)	(43.00, 43.10)
2003	43.06	0.086	(42.96, 43.28)	(42.99, 43.24)	(43.00, 43.12)	(43.00, 43.10)	(43.00, 43.10)
2004	43.11	0.797	(42.06, 45.02)	(42.10, 43.98)	(42.96, 43.37)	(42.97, 43.14)	(42.99, 43.13)
2005	43.27	0.478	(43.24, 43.29)	(43.24, 43.29)	(43.24, 43.29)	(43.27, 43.28)	(43.27, 43.27)
2007	43.29	0.013	(43.27, 43.30)	(43.27, 43.30)	(43.27, 43.30)	(43.27, 43.30)	(43.27, 43.30)

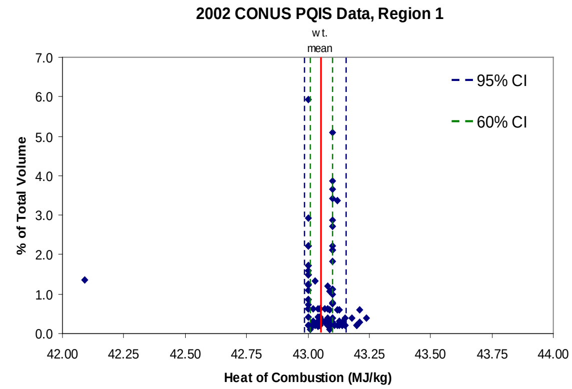
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 1 Based on the Weibull Distribution of PQIS Data from 1999-2007.

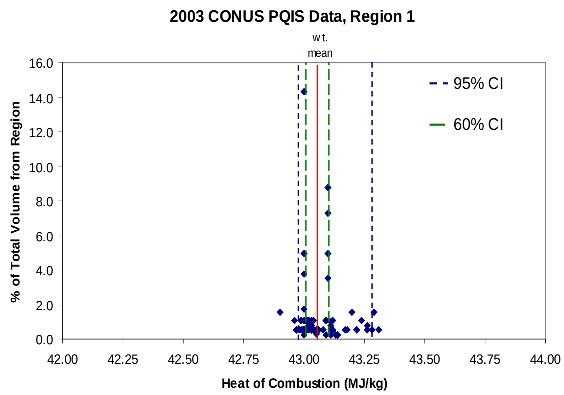
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.068	(43.08, 43.35)	(43.11, 43.33)	(43.14, 43.31)	(43.16, 43.30)	(43.17, 43.29)	0.910
2000	0.054	(43.07, 43.28)	(43.10, 43.27)	(43.13, 43.26)	(43.15, 43.25)	(43.16, 43.24)	0.860
2001	0.087	(43.02, 43.36)	(43.05, 43.33)	(43.08, 43.30)	(43.10, 43.28)	(43.12, 43.27)	0.932
2002	0.089	(42.84, 43.18)	(42.89, 43.17)	(42.94, 43.15)	(42.97, 43.13)	(42.99, 43.12)	0.715
2003	0.062	(42.94, 43.17)	(42.95, 43.15)	(42.97, 43.13)	(42.99, 43.12)	(43.00, 43.11)	0.916
2004	0.577	(41.90, 44.15)	(42.10, 44.00)	(42.33, 43.83)	(42.49, 43.70)	(42.62, 43.60)	0.718
2005	0.031	(43.19, 43.31)	(43.21, 43.31)	(43.23, 43.23)	(43.24, 43.29)	(43.24, 43.29)	0.465
2007	-	-	-	-	-	-	-

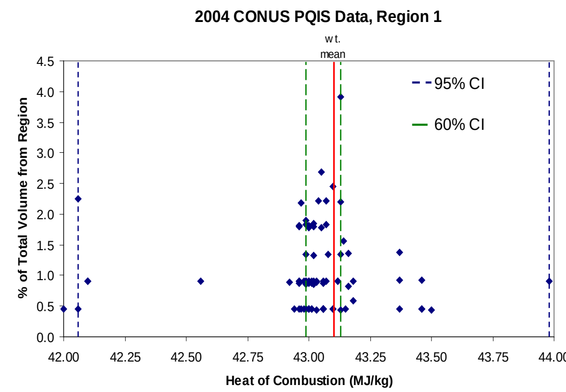


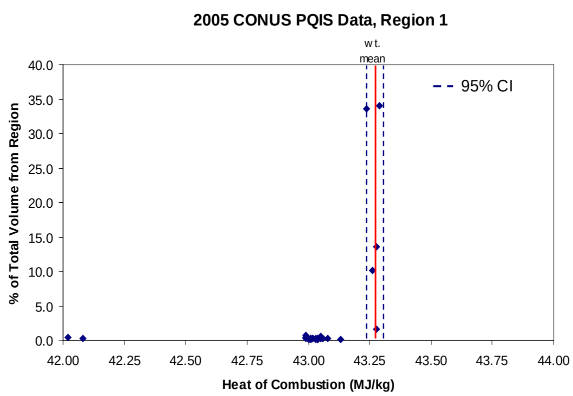


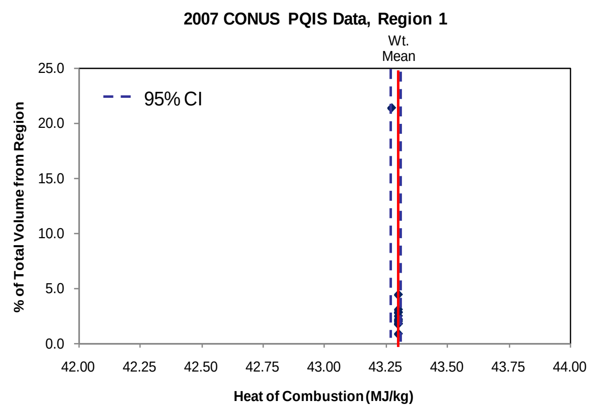

2001 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
42.00
42.25
42.50
42.75
43.00
43.25
43.50
43.75
44.00


2002 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume
Heat of Combustion (MJ/kg)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
42.00
42.25
42.50
42.75
43.00
43.25
43.50
43.75
44.00


2003 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
42.00
42.25
42.50
42.75
43.00
43.25
43.50
43.75
44.00


2004 CONUS PQIS Data, Region 1
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
42.00
42.25
42.50
42.75
43.00
43.25
43.50
43.75
44.00


2005 CONUS PQIS Data, Region 1
wt. mean
95% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
42.00
42.25
42.50
42.75
43.00
43.25
43.50
43.75
44.00

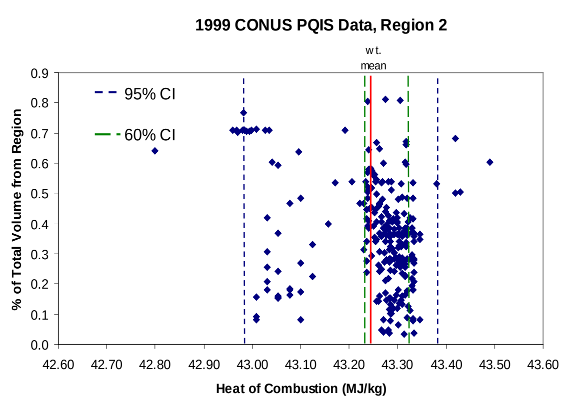

2007 CONUS PQIS Data, Region 1
Wt. Mean
95% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0
5.0
10.0
15.0
20.0
25.0
42.00
42.25
42.50
42.75
43.00
43.25
43.50
43.75
44.00

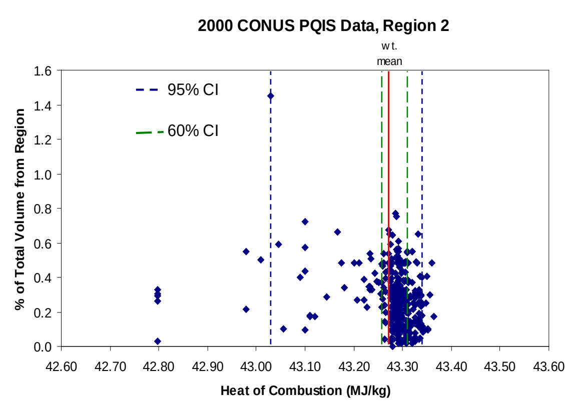
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 2 Based on PQIS Data from 1999-2008.

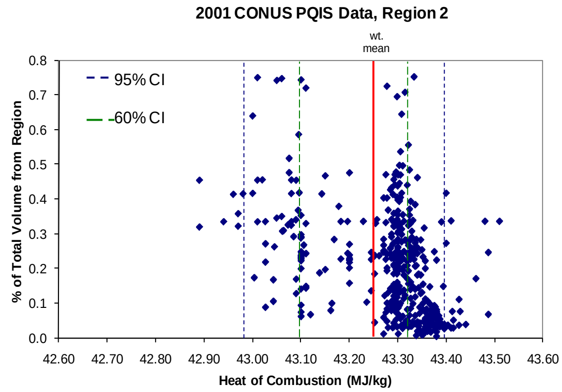
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	43.24	0.100	(42.98, 43.38)	(42.99, 43.34)	(43.04, 43.33)	(43.11, 43.32)	(43.24, 43.32)
2000	43.27	0.078	(43.03, 43.34)	(43.09, 43.33)	(43.21, 43.32)	(43.25, 43.31)	(43.26, 43.31)
2001	43.25	0.178	(42.98, 43.40)	(43.00, 43.38)	(43.06, 43.34)	(43.09, 43.33)	(43.10, 43.32)
2002	43.25	0.158	(43.02, 43.40)	(43.05, 43.39)	(43.07, 43.36)	(43.11, 43.33)	(43.15, 43.31)
2003	43.28	0.073	(43.10, 43.44)	(43.12, 43.40)	(43.16, 43.34)	(43.20, 43.31)	(43.28, 43.31)
2004	43.28	0.124	(43.00, 43.45)	(43.10, 43.43)	(43.13, 43.40)	(43.22, 43.34)	(43.25, 43.30)
2005	43.29	0.132	(43.10, 43.46)	(43.23, 43.45)	(43.24, 43.44)	(43.26, 43.43)	(43.28, 43.42)
2006	43.30	0.053	(43.16, 43.44)	(43.19, 43.41)	(43.22, 43.36)	(43.25, 43.36)	(43.26, 43.32)
2007	43.29	0.059	(43.15, 43.45)	(43.17, 43.44)	(43.22, 43.34)	(43.24, 43.33)	(43.25, 43.32)
2008	43.31	0.070	(43.20, 43.42)	(43.23, 43.40)	(43.25, 43.37)	(43.26, 43.36)	(43.28, 43.34)

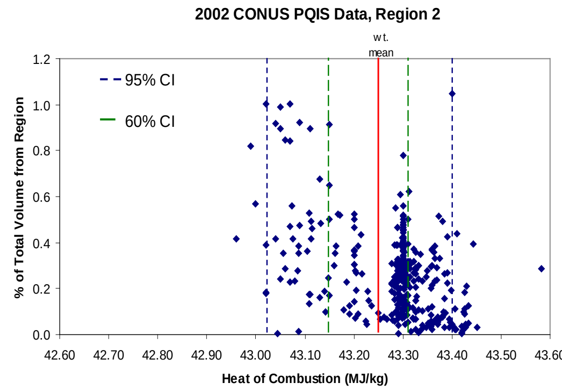
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 2 Based on the Weibull Distribution of PQIS Data from 1999-2008.

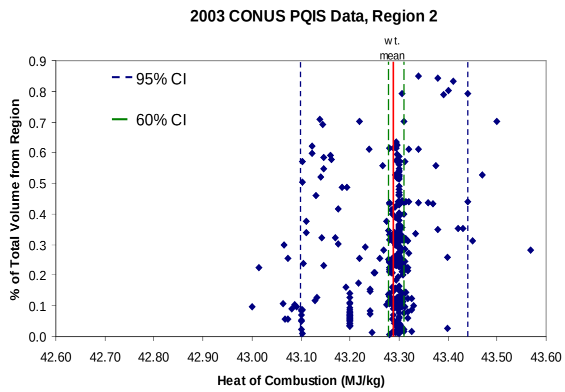
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.105	(42.99, 43.40)	(43.05, 43.38)	(43.11, 43.36)	(43.14, 43.34)	(43.17, 43.33)	0.945
2000	0.074	(43.09, 43.37)	(43.13, 43.36)	(43.17, 43.35)	(43.20, 43.34)	(43.21, 43.33)	0.885
2001	0.136	(42.99, 43.52)	(43.03, 43.48)	(43.08, 43.43)	(43.11, 43.40)	(43.14, 43.37)	0.922
2002	0.121	(43.03, 43.50)	(43.06, 43.46)	(43.10, 43.41)	(43.12, 43.38)	(43.15, 43.36)	0.948
2003	0.071	(43.13, 43.10)	(43.16, 43.39)	(43.19, 43.37)	(43.21, 43.36)	(43.23, 43.34)	0.932
2004	0.086	(43.07, 43.43)	(43.11, 43.41)	(43.15, 43.39)	(43.18, 43.37)	(43.20, 43.35)	0.948
2005	0.085	(43.13, 43.46)	(43.17, 43.44)	(43.21, 43.42)	(43.24, 43.41)	(43.26, 43.40)	0.929
2006	0.056	(43.18, 43.40)	(43.20, 43.39)	(43.22, 43.37)	(43.23, 43.35)	(43.25, 43.34)	0.964
2007	0.061	(43.16, 43.40)	(43.19, 43.39)	(43.21, 43.37)	(43.23, 43.36)	(43.24, 43.34)	0.969
2008	0.056	(43.18, 43.39)	(43.20, 43.38)	(43.23, 43.37)	(43.25, 43.36)	(43.27, 43.35)	0.889

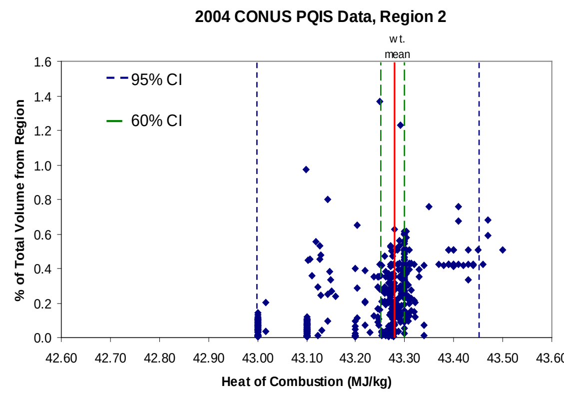


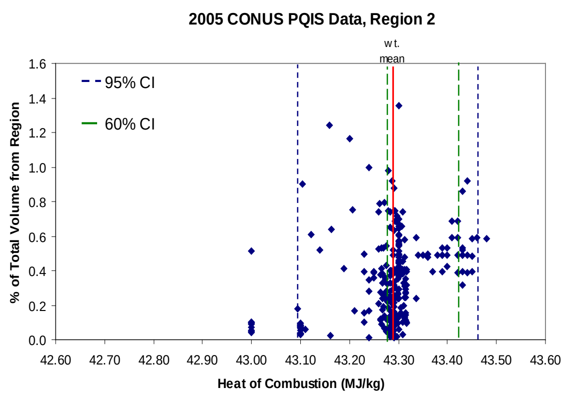


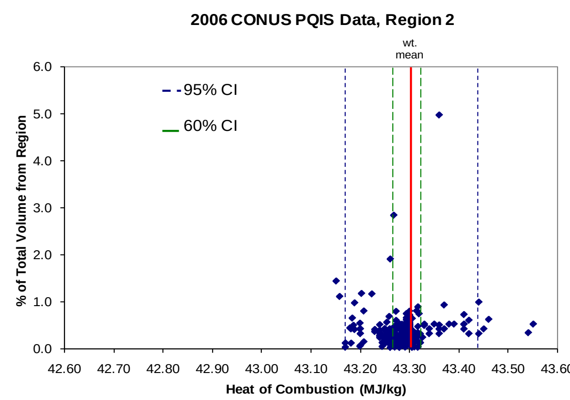

2001 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

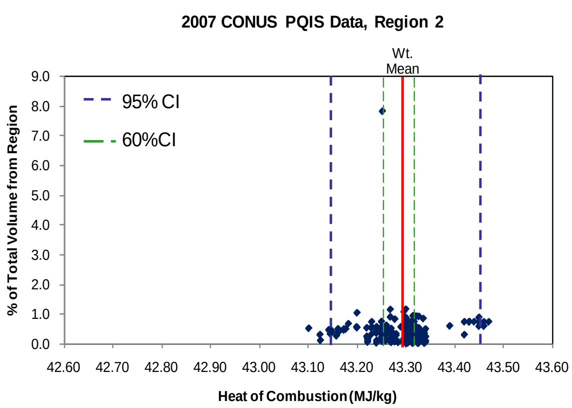

2002 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

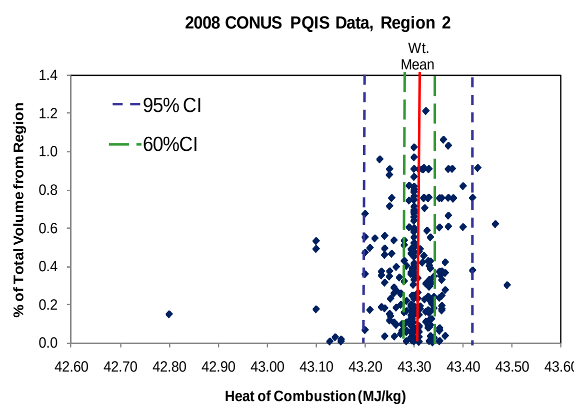

2003 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2004 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2005 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2006 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2007 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

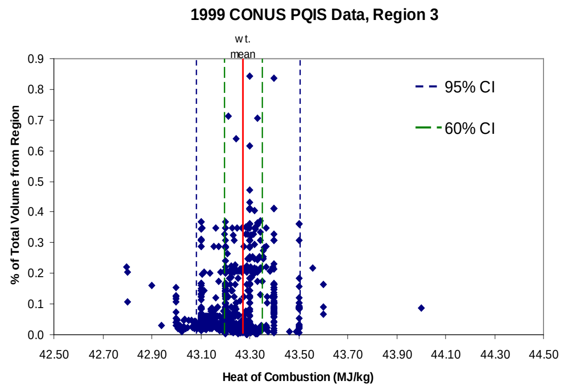

2008 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

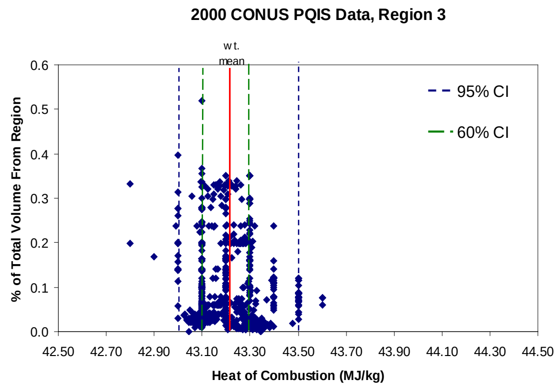
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 3 Based on PQIS Data from 1999-2008.

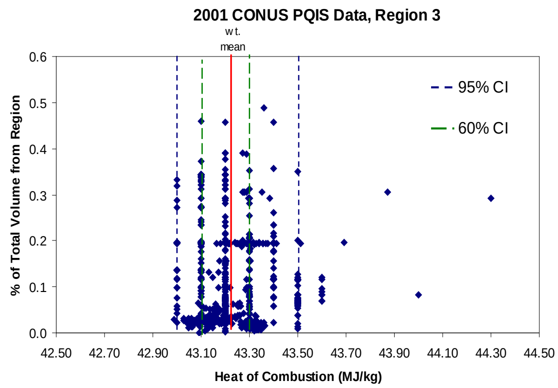
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	43.27	0.119	(43.08, 43.50)	(43.10, 43.40)	(43.11, 43.40)	(43.17, 43.40)	(43.20, 43.35)
2000	43.21	0.132	(43.00, 43.50)	(43.00, 43.40)	(43.10, 43.32)	(43.10, 43.30)	(43.10, 43.30)
2001	43.22	0.166	(43.00, 43.50)	(43.00, 43.50)	(43.10, 43.40)	(43.10, 43.36)	(43.10, 43.30)
2002	43.19	0.228	(43.00, 43.50)	(43.02, 43.50)	(43.10, 43.40)	(43.10, 43.30)	(43.10, 43.28)
2003	43.21	0.169	(43.05, 43.50)	(43.10, 43.40)	(43.10, 43.40)	(43.10, 43.33)	(43.10, 43.30)
2004	43.26	0.198	(43.06, 43.50)	(43.10, 43.50)	(43.10, 43.36)	(43.10, 43.33)	(43.15, 43.31)
2005	43.25	0.241	(43.10, 44.20)	(43.10, 43.50)	(43.10, 43.40)	(43.10, 43.31)	(43.10, 43.30)
2006	43.23	0.213	(43.08, 43.53)	(43.10, 43.40)	(43.10, 43.40)	(43.10, 43.37)	(43.10, 43.31)
2007	43.23	0.125	(43.00, 43.41)	(43.10, 43.41)	(43.10, 43.40)	(43.10, 43.39)	(43.10, 43.36)
2008	43.23	0.144	(43.00, 43.40)	(43.00, 43.40)	(43.10, 43.40)	(43.10, 43.37)	(43.20, 43.35)

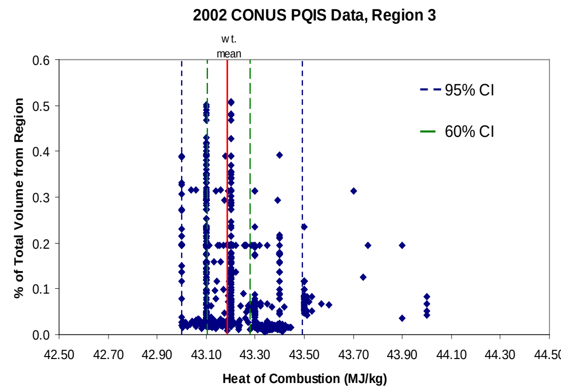
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 3 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

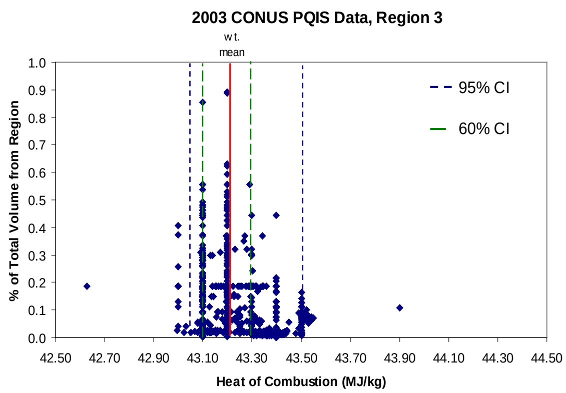
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.114	(43.05, 43.51)	(43.09, 43.46)	(43.14, 43.42)	(43.17, 43.39)	(43.19, 43.36)	0.972
2000	0.123	(42.97, 43.46)	(43.01, 43.41)	(43.07, 43.36)	(43.10, 43.33)	(43.12, 43.31)	0.959
2001	0.147	(42.93, 43.52)	(42.99, 43.46)	(43.05, 43.40)	(43.08, 43.37)	(43.11, 43.34)	0.917
2002	0.136	(43.91, 43.46)	(42.97, 43.41)	(43.02, 43.35)	(43.06, 43.32)	(43.08, 43.29)	0.855
2003	0.112	(43.00, 43.45)	(43.03, 43.39)	(43.07, 43.34)	(43.10, 43.31)	(43.12, 43.29)	0.942
2004	0.144	(43.00, 43.58)	(43.04, 43.50)	(43.09, 43.43)	(43.12, 43.39)	(43.14, 43.36)	0.896
2005	0.171	(43.00, 43.63)	(43.00, 43.54)	(43.05, 43.46)	(43.09, 43.41)	(43.12, 43.37)	0.824
2006	0.130	(43.01, 43.53)	(43.04, 43.45)	(43.08, 43.38)	(43.11, 43.34)	(43.13, 43.32)	0.955
2007	0.115	(43.02, 43.48)	(43.05, 43.42)	(43.09, 43.37)	(43.12, 32.33)	(43.14, 32.31)	0.963
2008	0.111	(43.01, 43.46)	(43.06, 43.41)	(43.10, 43.37)	(43.13, 43.34)	(43.15, 43.32)	0.956

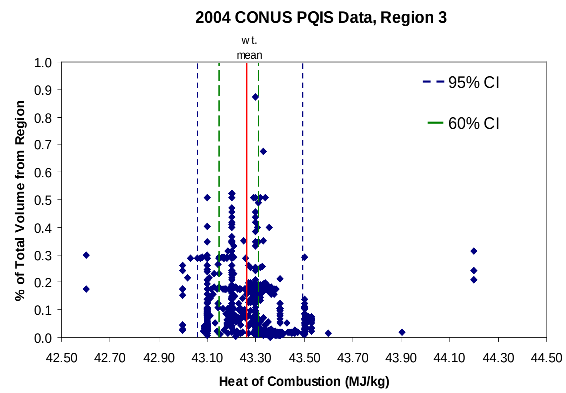


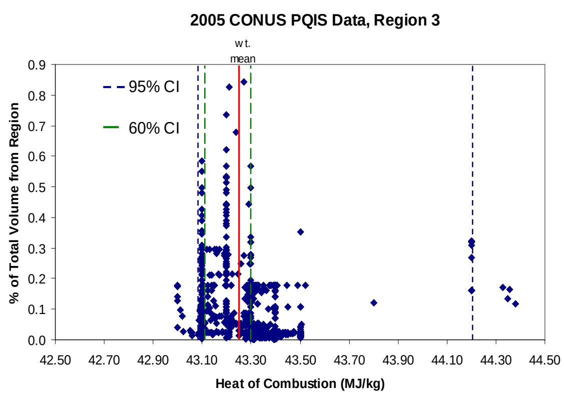


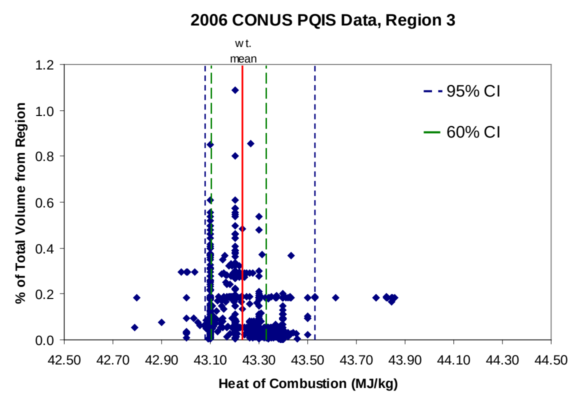

2001 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0 0.1 0.2 0.3 0.4 0.5 0.6
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50

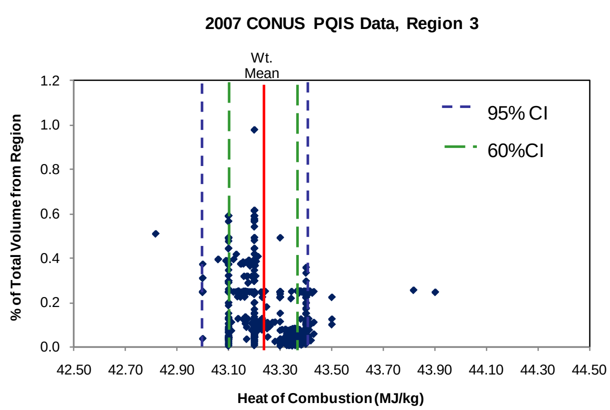

2002 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0 0.1 0.2 0.3 0.4 0.5 0.6
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50

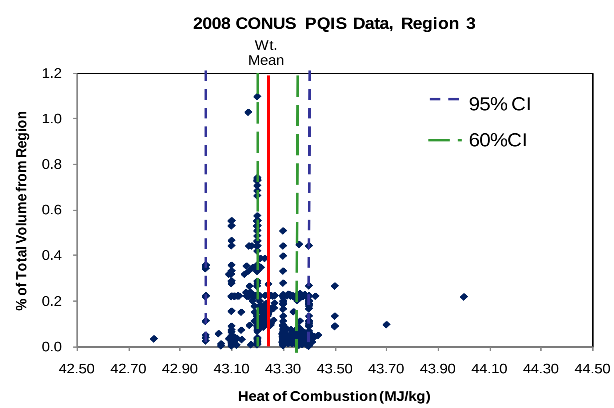

2003 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50


2004 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50


2005 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50


2006 CONUS PQIS Data, Region 3
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)
0.0 0.2 0.4 0.6 0.8 1.0 1.2
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50


2007 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion(MJ/kg)
0.0 0.2 0.4 0.6 0.8 1.0 1.2
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50

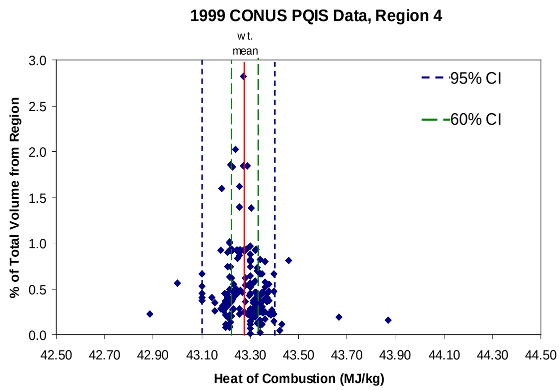

2008 CONUS PQIS Data, Region 3
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion(MJ/kg)
0.0 0.2 0.4 0.6 0.8 1.0 1.2
42.50 42.70 42.90 43.10 43.30 43.50 43.70 43.90 44.10 44.30 44.50

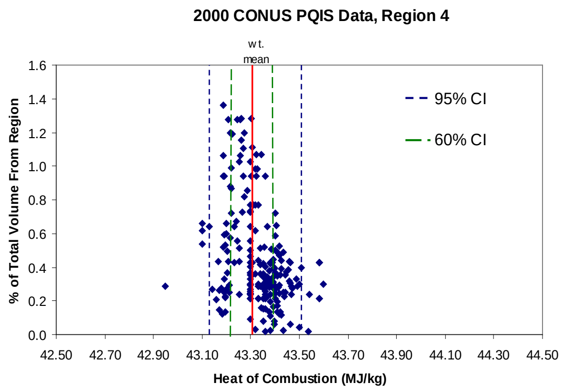
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 4 Based on PQIS Data from 1999-2008.

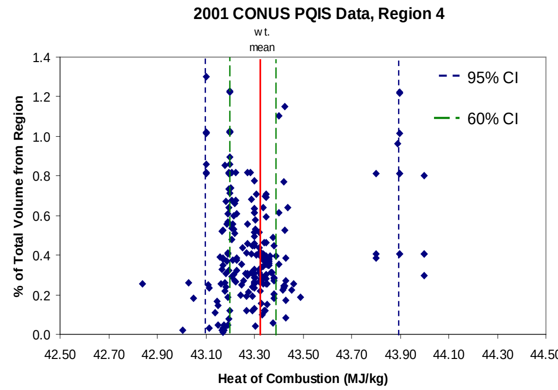
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	43.27	0.163	(43.10, 43.40)	(43.18, 43.38)	(43.20, 43.36)	(43.21, 43.34)	(43.22, 43.33)
2000	43.31	0.104	(43.13, 43.51)	(43.18, 43.46)	(43.19, 43.42)	(43.21, 43.40)	(43.22, 43.39)
2001	43.32	0.187	(43.10, 43.90)	(43.10, 43.90)	(43.16, 43.80)	(43.18, 43.42)	(43.20, 43.38)
2002	43.28	0.219	(43.00, 43.85)	(43.00, 43.80)	(43.10, 43.80)	(43.10, 43.39)	(43.10, 43.37)
2003	43.21	0.090	(43.00, 43.38)	(43.00, 43.31)	(43.10, 43.30)	(43.17, 43.30)	(43.20, 43.28)
2004	43.22	0.111	(43.10, 43.40)	(43.10, 43.33)	(43.14, 43.30)	(43.20, 43.28)	(43.20, 43.25)
2005	43.27	0.162	(43.10, 43.90)	(43.10, 43.40)	(43.13, 43.35)	(43.18, 43.33)	(43.20, 43.30)
2006	43.25	0.173	(43.10, 43.90)	(43.10, 43.31)	(43.10, 43.30)	(43.10, 43.30)	(43.14, 43.30)
2007	43.24	0.265	(43.00, 43.96)	(43.00, 43.96)	(43.10, 43.30)	(43.10, 43.30)	(43.10, 43.30)
2008	43.24	0.159	(43.10, 43.44)	(43.10, 43.40)	(43.13, 43.34)	(43.14, 43.30)	(43.15, 43.30)

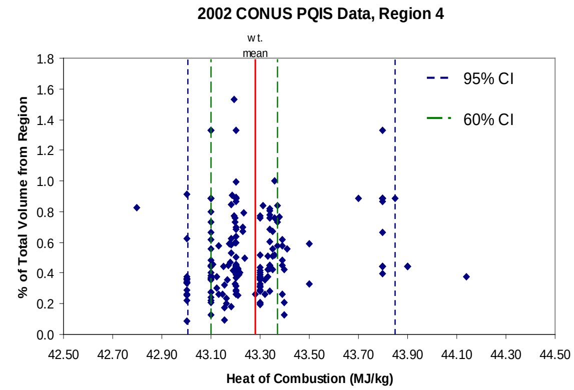
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 4 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

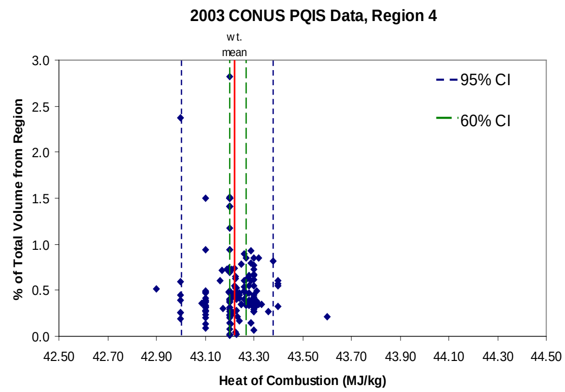
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.109	(43.07, 43.51)	(43.10, 43.46)	(43.14, 43.41)	(43.17, 43.38)	(43.19, 43.36)	0.779
2000	0.095	(43.13, 43.51)	(43.16, 43.47)	(43.20, 43.43)	(43.22, 43.40)	(43.24, 43.38)	0.991
2001	0.183	(43.05, 43.75)	(43.08, 43.64)	(43.13, 43.53)	(43.16, 43.48)	(43.18, 43.43)	0.937
2002	0.217	(42.96, 43.80)	(43.01, 43.66)	(43.06, 43.54)	(43.09, 43.47)	(43.12, 43.42)	0.959
2003	0.077	(43.06, 43.37)	(43.09, 43.34)	(43.12, 43.31)	(43.14, 43.29)	(43.16, 43.27)	0.949
2004	0.082	(43.10, 43.38)	(43.12, 43.34)	(43.14, 43.30)	(43.15, 43.28)	(43.16, 43.27)	0.891
2005	0.122	(43.06, 43.54)	(43.09, 43.48)	(43.13, 43.42)	(43.15, 43.38)	(43.17, 43.35)	0.916
2006	0.146	(43.09, 43.58)	(43.11, 43.47)	(43.13, 43.38)	(43.14, 43.34)	(43.15, 43.31)	0.929
2007	0.213	(42.98, 43.74)	(43.01, 43.59)	(43.04, 43.46)	(43.07, 43.39)	(43.09, 43.35)	0.948
2008	0.125	(43.10, 43.53)	(43.11, 43.44)	(43.13, 43.37)	(43.15, 43.33)	(43.16, 43.30)	0.973

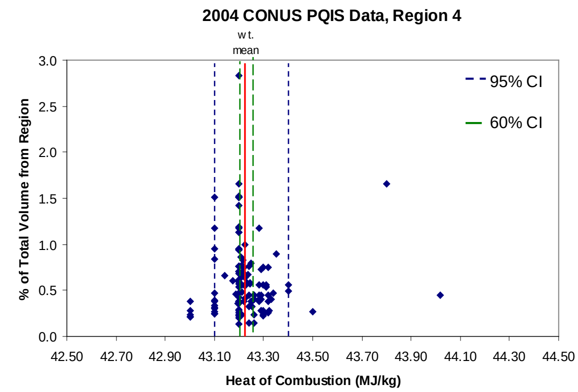


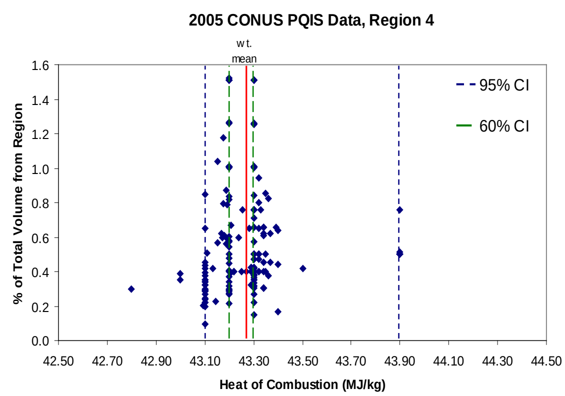


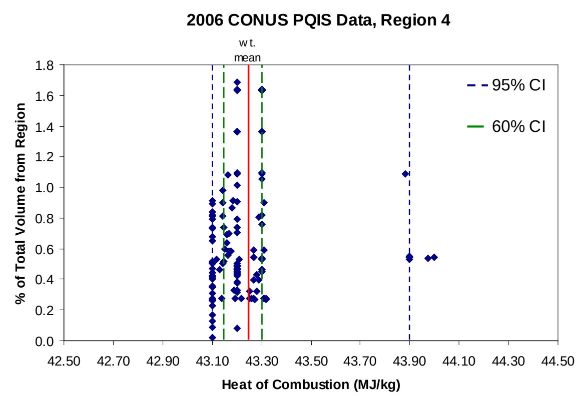

2001 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

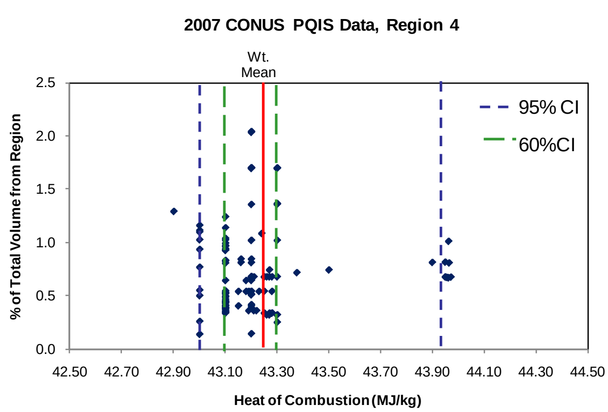

2002 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

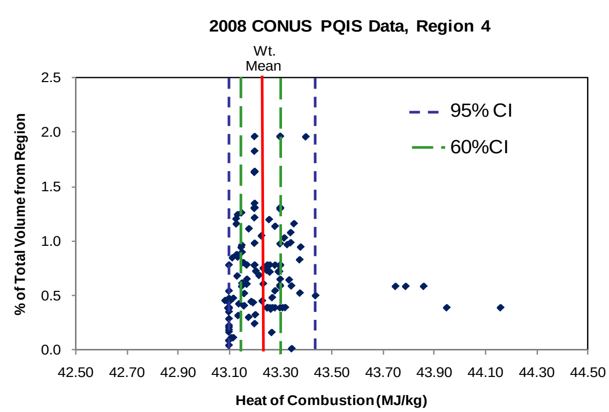

2003 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2004 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2005 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2006 CONUS PQIS Data, Region 4
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2007 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

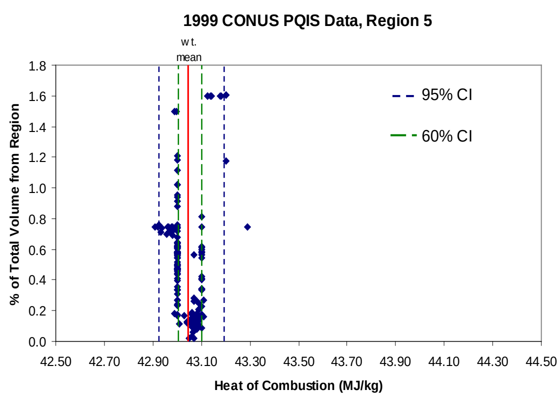

2008 CONUS PQIS Data, Region 4
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

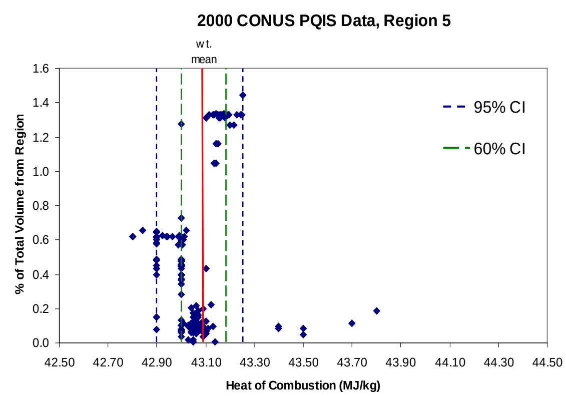
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 5 Based on PQIS Data from 1999-2008.

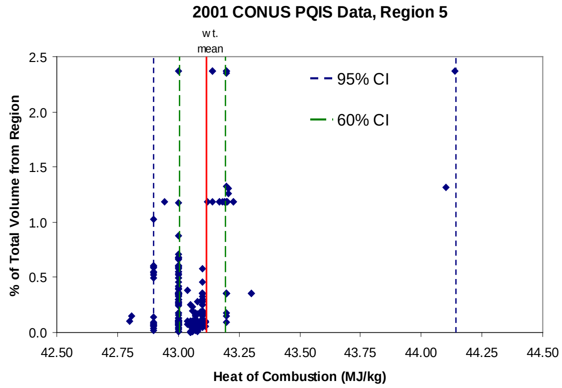
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	43.04	0.088	(42.93, 43.20)	(42.96, 43.20)	(42.98, 43.14)	(43.00, 43.12)	(43.00, 43.10)
2000	43.09	0.125	(42.90, 43.25)	(42.90, 43.23)	(42.92, 43.19)	(43.00, 43.18)	(43.00, 43.17)
2001	43.12	0.130	(42.90, 44.14)	(42.90, 43.23)	(43.00, 43.20)	(43.00, 43.19)	(43.00, 43.19)
2002	43.21	0.251	(42.90, 44.14)	(42.90, 44.10)	(43.00, 44.10)	(43.00, 43.30)	(43.00, 43.25)
2003	43.11	0.171	(42.90, 44.16)	(42.90, 44.13)	(42.90, 43.20)	(43.00, 43.19)	(43.00, 43.16)
2004	43.13	0.202	(42.90, 44.30)	(42.90, 44.20)	(42.90, 43.30)	(43.00, 43.30)	(43.00, 43.24)
2005	43.16	0.184	(42.90, 44.16)	(43.00, 44.00)	(43.00, 43.32)	(43.00, 43.30)	(43.00, 43.26)
2006	43.08	0.694	(43.00, 43.24)	(43.00, 43.23)	(43.00, 43.21)	(43.00, 43.20)	(43.00, 43.19)
2007	43.12	0.125	(43.00, 43.22)	(43.00, 43.20)	(43.00, 43.20)	(43.00, 43.19)	(43.00, 43.18)
2008	43.11	0.116	(43.00, 43.80)	(43.00, 43.21)	(43.00, 43.18)	(43.00, 43.16)	(43.00, 43.15)

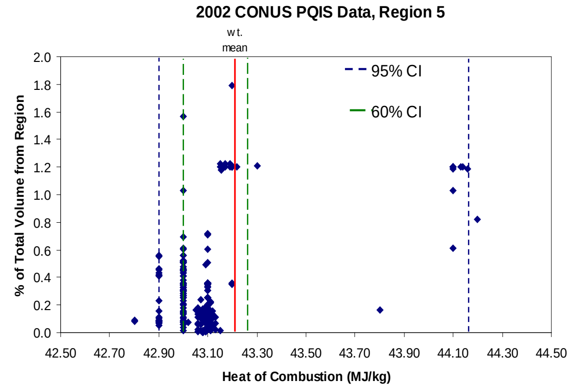
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from Region 5 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

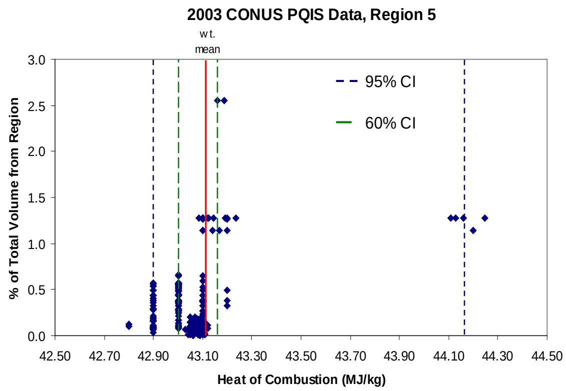
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.085	(42.87, 43.21)	(42.90, 43.17)	(42.93, 43.14)	(42.96, 43.12)	(42.97, 43.10)	0.817
2000	0.107	(42.88, 43.32)	(42.92, 43.27)	(42.96, 43.22)	(42.99, 43.19)	(43.01, 43.17)	0.952
2001	0.167	(42.91, 43.52)	(42.93, 43.40)	(42.96, 43.30)	(42.98, 43.25)	(43.00, 43.21)	0.939
2002	0.320	(42.90, 43.93)	(42.93, 43.70)	(42.96, 43.50)	(42.99, 43.40)	(43.01, 43.34)	0.916
2003	0.203	(42.89, 43.59)	(42.91, 43.44)	(42.94, 43.31)	(42.96, 43.25)	(42.98, 43.20)	0.924
2004	0.214	(42.77, 43.54)	(42.82, 43.43)	(42.88, 43.33)	(42.92, 43.27)	(42.95, 43.23)	0.846
2005	0.230	(42.89, 43.70)	(42.92, 43.54)	(42.96, 43.40)	(42.98, 43.32)	(43.00, 43.27)	0.949
2006	0.083	(42.91, 43.25)	(42.95, 43.22)	(42.98, 43.18)	(43.00, 43.16)	(43.02, 43.14)	0.916
2007	0.103	(42.95, 43.35)	(42.97, 43.29)	(43.00, 43.23)	(43.02, 43.20)	(43.03, 43.18)	0.878
2008	0.115	(42.95, 43.38)	(42.97, 43.30)	(42.99, 43.23)	(43.01, 43.19)	(43.02, 43.17)	0.909

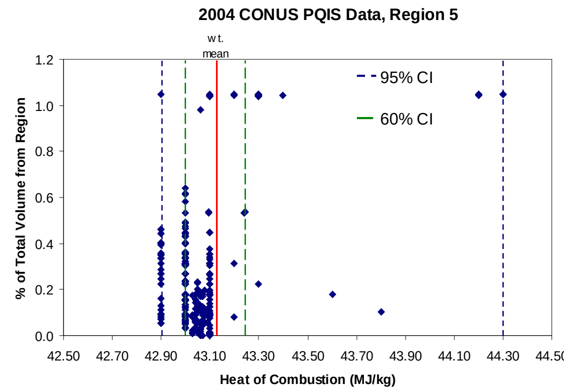


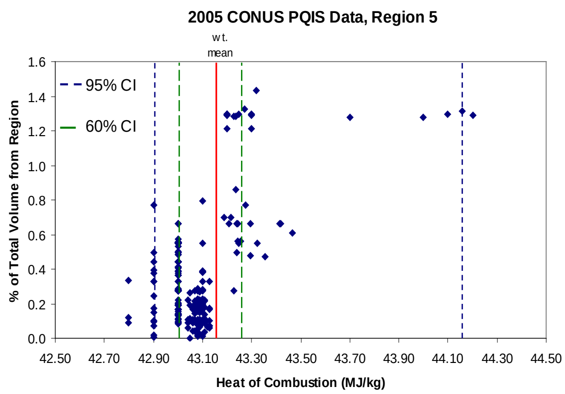


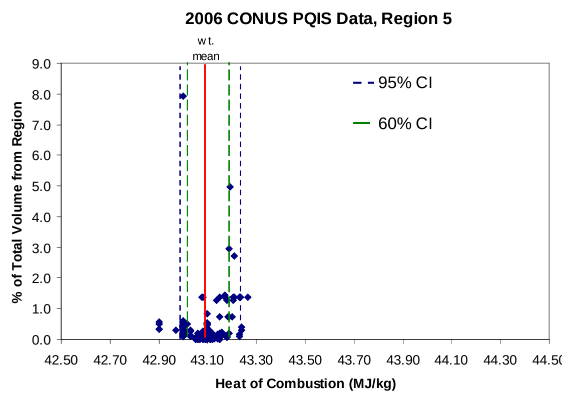

2001 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

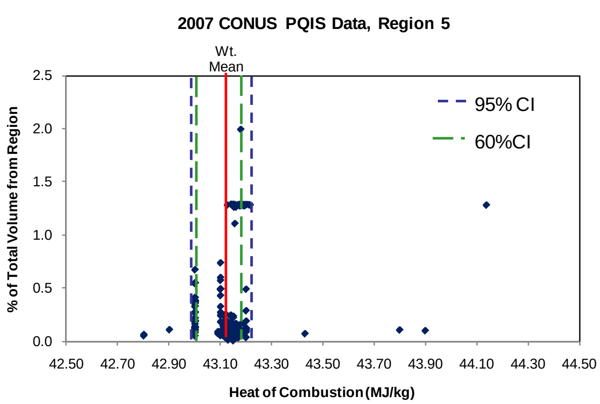

2002 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

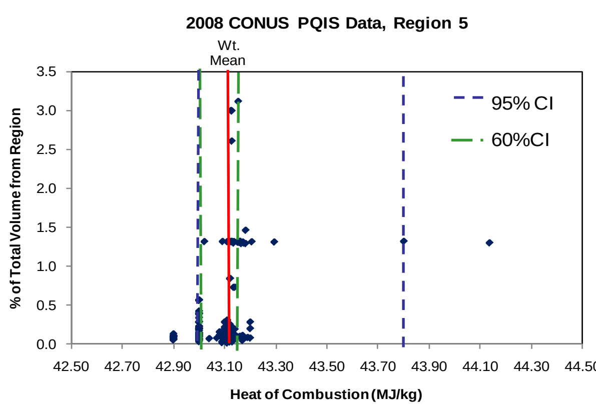

2003 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2004 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2005 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2006 CONUS PQIS Data, Region 5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)


2007 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

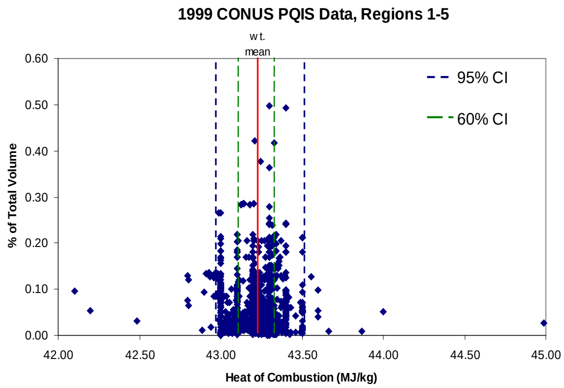

2008 CONUS PQIS Data, Region 5
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Heat of Combustion (MJ/kg)

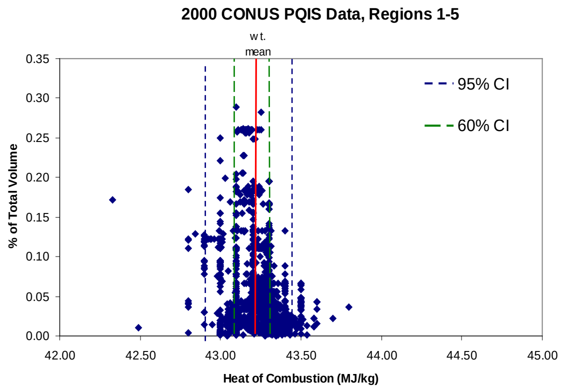
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from CONUS Based on PQIS Data from 1999-2008.

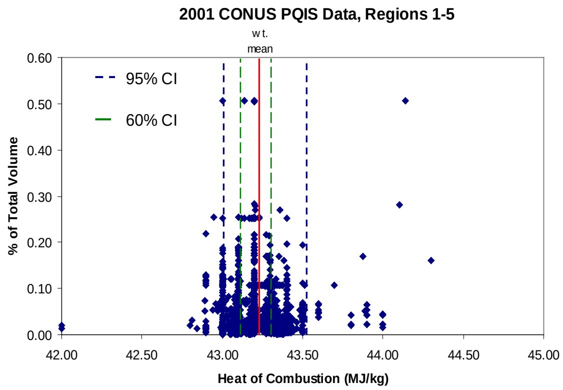
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	43.22	0.137	(42.98, 43.50)	(43.00, 43.40)	(43.00, 43.40)	(43.08, 43.33)	(43.10, 43.31)
2000	43.20	0.139	(42.90, 43.43)	(43.00, 43.40)	(43.01, 43.32)	(43.10, 43.30)	(43.10, 43.30)
2001	43.21	0.180	(43.00, 43.51)	(43.00, 43.46)	(43.00, 43.40)	(43.09, 43.33)	(43.10, 43.30)
2002	43.21	0.365	(43.00, 44.10)	(43.00, 43.50)	(43.01, 43.40)	(43.10, 43.33)	(43.10, 43.30)
2003	43.20	0.162	(43.00, 43.50)	(43.00, 43.40)	(43.00, 43.36)	(43.10, 43.31)	(43.10, 43.30)
2004	43.23	0.255	(42.90, 43.60)	(43.00, 43.47)	(43.00, 43.36)	(43.06, 43.32)	(43.10, 43.30)
2005	43.25	0.204	(43.00, 44.20)	(43.00, 43.50)	(43.08, 43.40)	(43.10, 43.34)	(43.10, 43.31)
2006	43.21	0.189	(43.00, 43.50)	(43.00, 43.40)	(43.05, 43.38)	(43.10, 43.33)	(43.10, 43.30)
2007	43.21	0.155	(43.00, 43.43)	(43.00, 43.40)	(43.00, 43.40)	(43.10, 43.34)	(43.10, 43.30)
2008	43.21	0.154	(43.00, 43.40)	(43.00, 43.40)	(43.00, 43.38)	(43.10, 43.35)	(43.10, 43.31)

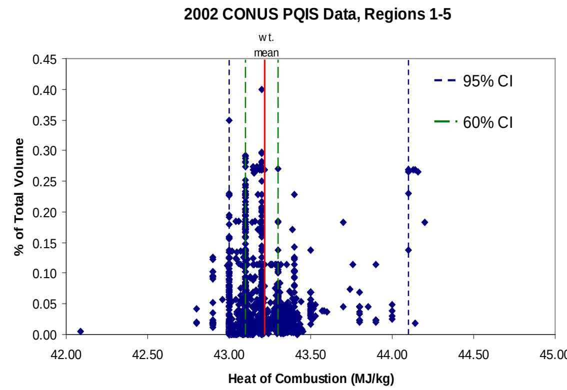
Statistics and Confidence Intervals for the Heat of Combustion (MJ/kg) of JP-8 Fuel from CONUS Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

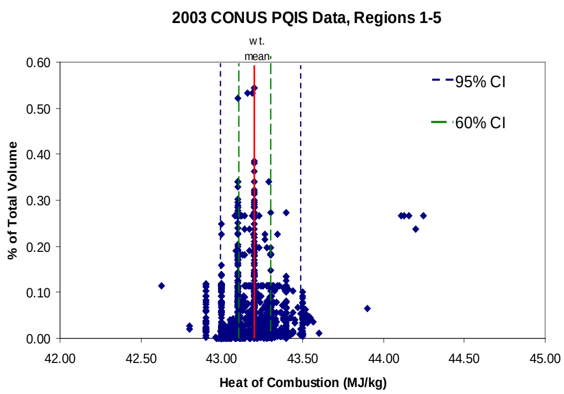
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.136	(42.95, 43.50)	(43.00, 43.45)	(43.06, 43.39)	(43.09, 43.35)	(43.12, 43.33)	0.960
2000	0.128	(42.95, 43.46)	(43.00, 43.41)	(43.05, 43.36)	(43.08, 43.33)	(43.11, 43.30)	0.979
2001	0.168	(42.88, 43.56)	(42.94, 43.49)	(43.01, 43.42)	(43.05, 43.37)	(43.08, 43.34)	0.904
2002	0.188	(42.85, 43.61)	(42.91, 43.52)	(42.98, 43.44)	(43.03, 43.39)	(43.06, 43.35)	0.868
2003	0.151	(42.94, 43.54)	(42.98, 43.46)	(43.03, 43.38)	(43.06, 43.34)	(43.08, 43.30)	0.966
2004	0.182	(42.89, 43.62)	(42.95, 43.54)	(43.02, 43.45)	(43.06, 43.40)	(43.09, 43.37)	0.909
2005	0.184	(42.92, 43.65)	(42.97, 43.56)	(43.03, 43.47)	(43.07, 43.42)	(43.10, 43.38)	0.905
2006	0.140	(42.98, 43.53)	(43.02, 43.45)	(43.05, 43.38)	(43.08, 43.33)	(43.10, 43.30)	0.979
2007	0.135	(42.98, 43.51)	(43.01, 43.44)	(43.05, 43.37)	(43.08, 43.33)	(43.10, 43.30)	0.972
2008	0.131	(42.96, 43.49)	(43.01, 43.43)	(43.05, 43.37)	(43.09, 43.34)	(43.11, 43.31)	0.957

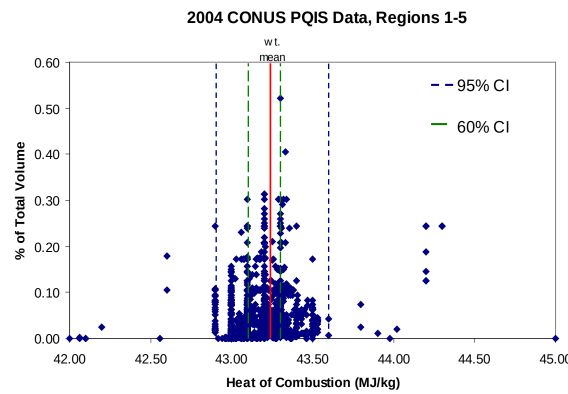


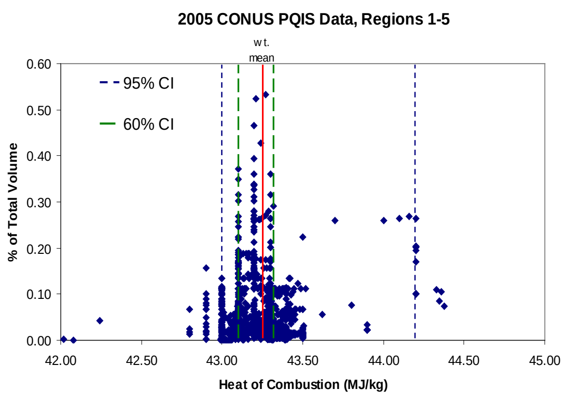


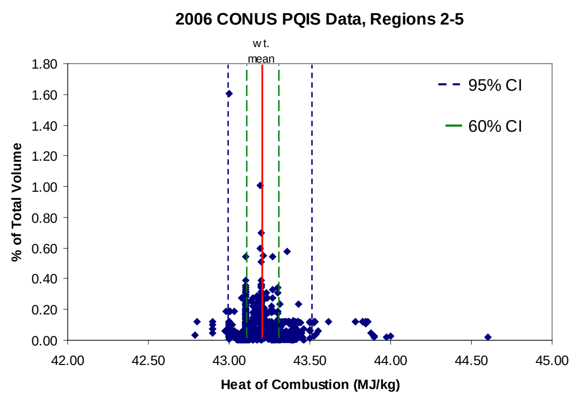

2001 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Heat of Combustion (MJ/kg)

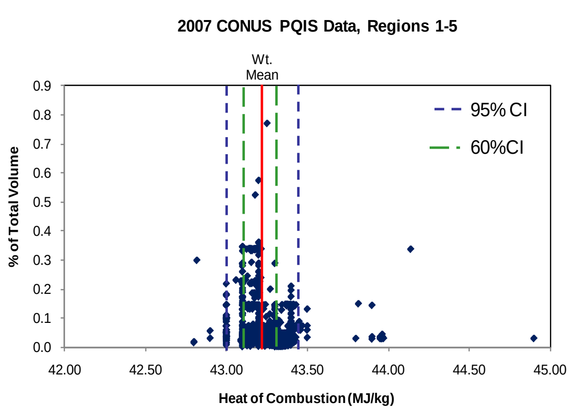

2002 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Heat of Combustion (MJ/kg)

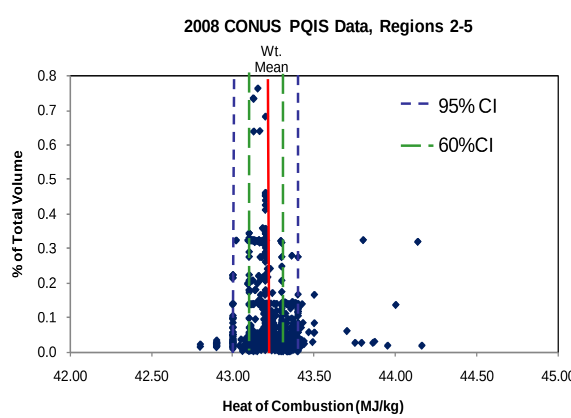

2003 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Heat of Combustion (MJ/kg)


2004 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Heat of Combustion (MJ/kg)


2005 CONUS PQIS Data, Regions 1-5
wt.
mean
95% CI
60% CI
% of Total Volume
Heat of Combustion (MJ/kg)


2006 CONUS PQIS Data, Regions 2-5
wt.
mean
95% CI
60% CI
% of Total Volume
Heat of Combustion (MJ/kg)


2007 CONUS PQIS Data, Regions 1-5
Wt.
Mean
95% CI
60%CI
% of Total Volume
Heat of Combustion (MJ/kg)


2008 CONUS PQIS Data, Regions 2-5
Wt.
Mean
95% CI
60%CI
% of Total Volume
Heat of Combustion (MJ/kg)

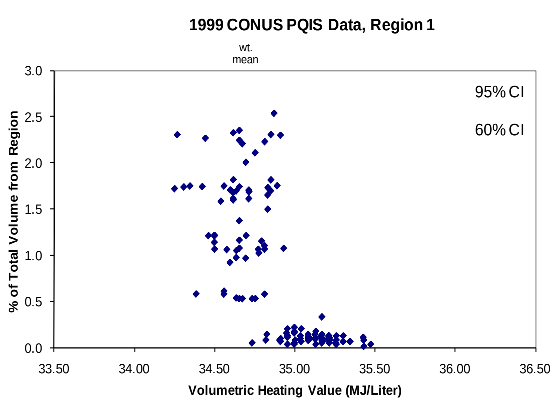
7.6 Volumetric Heating Value

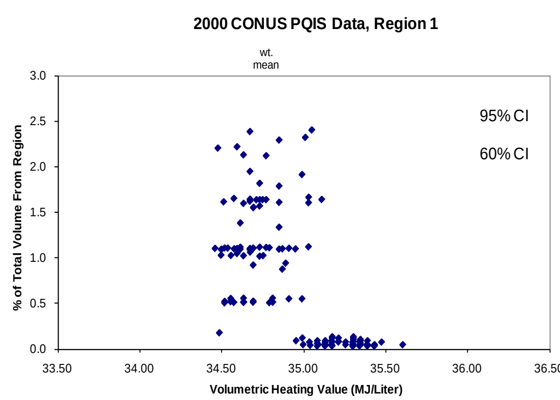
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 1 Based on PQIS Data from 1999-2007.

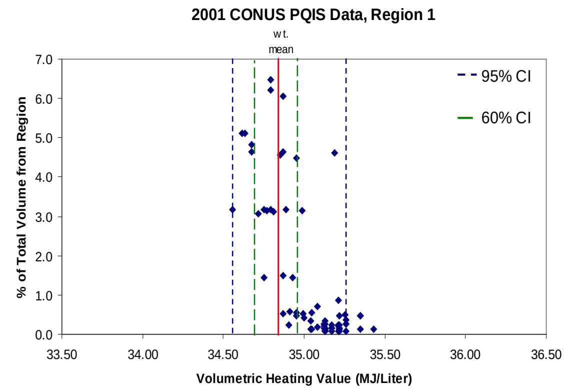
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	34.68	0.36	(34.26, 35.18)	(34.31, 35.02)	(34.44, 34.89)	(34.50, 34.84)	(34.52, 34.84)
2000	34.76	0.29	(34.47, 35.18)	(34.50, 35.05)	(34.50, 35.02)	(34.55, 34.97)	(34.58, 34.89)
2001	34.84	0.29	(34.55, 35.26)	(34.63, 35.21)	(34.66, 35.18)	(34.68, 34.97)	(34.68, 34.95)
2002	35.13	0.20	(34.87, 35.45)	(34.92, 35.39)	(34.95, 35.29)	(34.97, 35.24)	(35.02, 35.21)
2003	35.21	0.25	(34.71, 35.50)	(34.81, 35.45)	(34.92, 35.39)	(35.00, 35.39)	(35.02, 35.39)
2004	35.21	0.50	(34.34, 36.29)	(34.39, 35.66)	(34.63, 35.61)	(34.71, 35.53)	(34.97, 35.42)
2005	34.39	0.89	(34.31, 35.29)	(34.31, 34.42)	(34.31, 34.39)	(34.31, 34.39)	(34.31, 34.39)
2007	34.34	0.06	(34.27, 34.42)	(34.27, 34.42)	(34.27, 34.42)	(34.27, 34.42)	(34.27, 34.42)

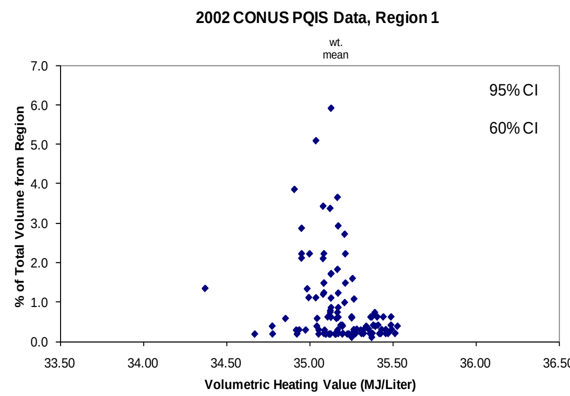
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 1 Based on the Loglogistic Distribution of PQIS Data from 1999-2007.

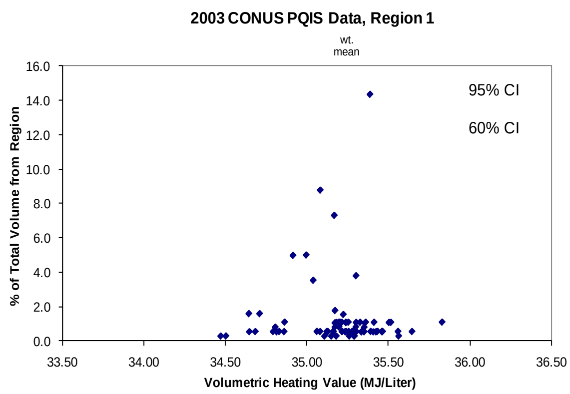
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.20	(34.29, 35.10)	(34.37, 35.00)	(34.44, 34.92)	(34.50, 34.87)	(34.52, 34.84)	0.987
2000	0.20	(34.47, 35.24)	(34.50, 35.10)	(34.55, 34.97)	(34.58, 34.89)	(34.58, 34.84)	0.983
2001	0.19	(34.58, 35.29)	(34.63, 35.18)	(34.66, 35.05)	(34.68, 35.00)	(34.71, 34.95)	0.978
2002	0.15	(34.58, 35.18)	(34.66, 35.13)	(34.71, 35.05)	(34.76, 35.00)	(34.79, 34.97)	0.959
2003	0.21	(35.05, 35.92)	(35.16, 35.84)	(35.26, 35.76)	(35.29, 35.71)	(35.34, 35.68)	0.982
2004	0.46	(34.37, 36.48)	(34.50, 36.19)	(34.66, 35.87)	(34.73, 35.71)	(34.81, 35.61)	0.961
2005	0.08	(34.29, 34.44)	(34.31, 34.42)	(34.31, 34.39)	(34.31, 34.39)	(34.31, 34.39)	0.861
2007	0.06	(34.23, 34.45)	(34.25, 34.43)	(34.27, 34.40)	(34.29, 34.39)	(34.30, 34.38)	0.855

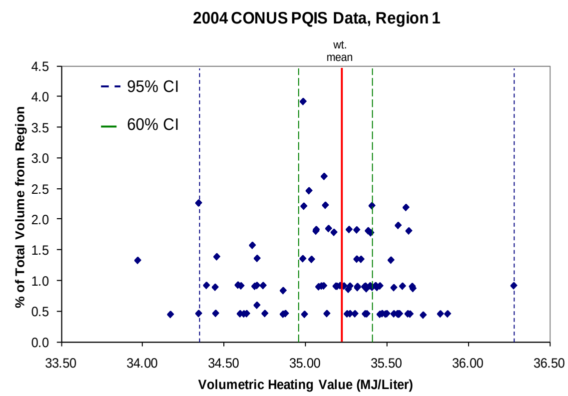


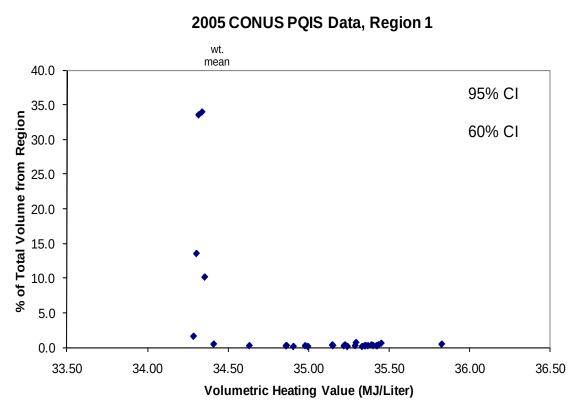


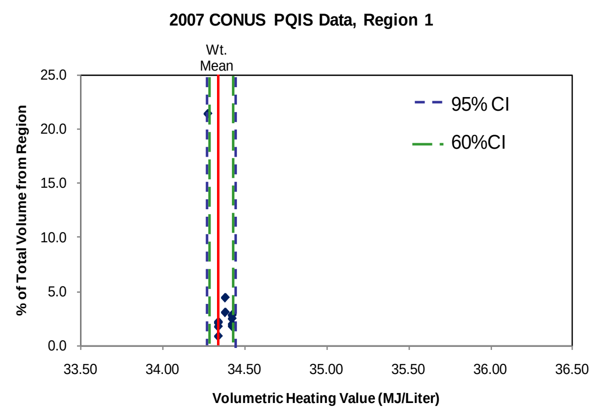

2001 CONUS PQIS Data, Region 1
wt.
mean
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
95% CI
60% CI
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
33.50
34.00
34.50
35.00
35.50
36.00
36.50


2002 CONUS PQIS Data, Region 1
wt.
mean
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
95% CI
60% CI
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
33.50
34.00
34.50
35.00
35.50
36.00
36.50


2003 CONUS PQIS Data, Region 1
wt.
mean
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
95% CI
60% CI
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
33.50
34.00
34.50
35.00
35.50
36.00
36.50


2004 CONUS PQIS Data, Region 1
wt.
mean
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
95% CI
60% CI
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
33.50
34.00
34.50
35.00
35.50
36.00
36.50


2005 CONUS PQIS Data, Region 1
wt.
mean
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
95% CI
60% CI
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
33.50
34.00
34.50
35.00
35.50
36.00
36.50

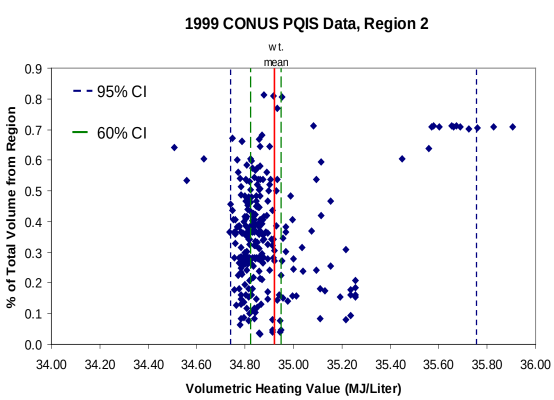

2007 CONUS PQIS Data, Region 1
Wt.
Mean
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
95% CI
60%CI
0.0
5.0
10.0
15.0
20.0
25.0
33.50
34.00
34.50
35.00
35.50
36.00
36.50

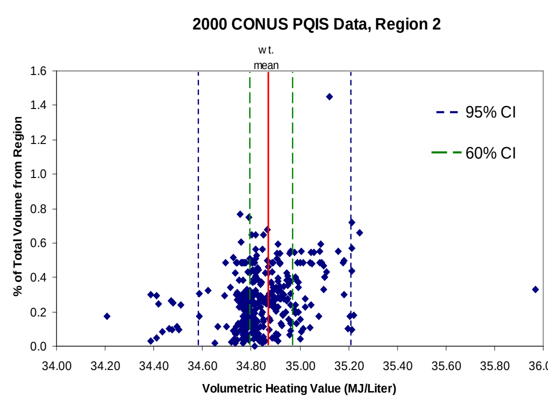
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 2 Based on PQIS Data from 1999-2008.

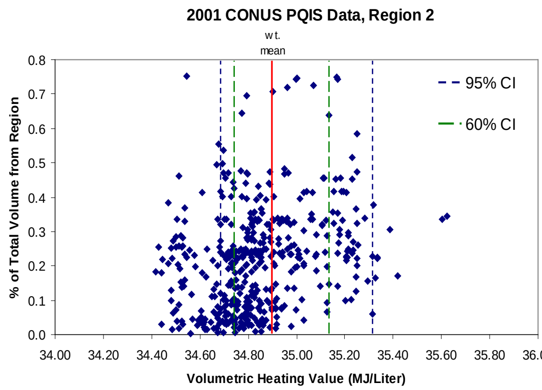
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	34.92	0.20	(34.73, 35.74)	(34.76, 35.66)	(34.79, 35.24)	(34.79, 35.02)	(34.81, 34.95)
2000	34.87	0.15	(34.58, 35.21)	(34.73, 35.16)	(34.76, 35.10)	(34.76, 35.00)	(34.79, 34.97)
2001	34.89	0.25	(34.68, 35.32)	(34.68, 35.26)	(34.71, 35.21)	(34.73, 35.18)	(34.73, 35.13)
2002	34.92	0.25	(34.47, 35.26)	(34.52, 35.21)	(34.71, 35.16)	(34.76, 35.10)	(34.81, 35.13)
2003	34.92	0.24	(34.42, 35.34)	(34.50, 35.24)	(34.73, 35.13)	(34.81, 35.02)	(34.84, 35.02)
2004	34.87	0.28	(34.55, 35.47)	(34.58, 35.34)	(34.79, 35.13)	(34.84, 35.10)	(34.87, 34.95)
2005	34.89	0.19	(34.66, 35.05)	(34.66, 35.02)	(34.73, 35.00)	(34.81, 34.97)	(34.84, 34.95)
2006	34.89	0.17	(34.63, 35.13)	(34.66, 35.10)	(34.73, 35.00)	(34.79, 34.97)	(34.81, 34.95)
2007	34.81	0.09	(34.67, 35.13)	(34.69, 34.97)	(34.71, 34.88)	(34.74, 34.86)	(34.75, 34.86)
2008	34.84	0.16	(34.62, 35.16)	(34.63, 35.12)	(34.69, 35.07)	(34.71, 35.00)	(34.72, 34.95)

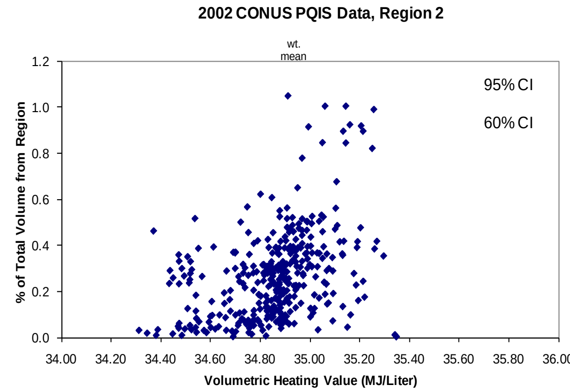
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 2 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

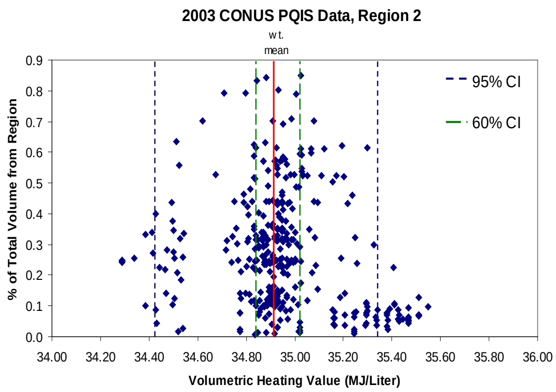
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.19	(34.66, 35.37)	(34.68, 35.26)	(34.73, 35.16)	(34.76, 35.10)	(34.79, 35.02)	0.906
2000	0.15	(34.58, 35.21)	(34.66, 35.13)	(34.71, 35.05)	(34.73, 35.00)	(34.76, 34.97)	0.962
2001	0.26	(34.50, 35.50)	(34.55, 35.34)	(34.63, 35.21)	(34.68, 35.13)	(34.71, 35.05)	0.985
2002	0.24	(34.55, 35.50)	(34.63, 35.34)	(34.68, 35.21)	(34.71, 35.16)	(34.76, 35.10)	0.934
2003	0.19	(34.52, 35.29)	(34.63, 35.21)	(34.71, 35.16)	(34.73, 35.10)	(34.76, 35.05)	0.968
2004	0.18	(34.63, 35.34)	(34.71, 35.26)	(34.76, 35.21)	(34.81, 35.16)	(34.84, 35.05)	0.963
2005	0.11	(34.68, 35.16)	(34.73, 35.10)	(34.76, 35.02)	(34.79, 35.00)	(34.81, 34.97)	0.953
2006	0.13	(34.55, 35.21)	(34.71, 35.13)	(34.76, 35.05)	(34.76, 35.00)	(34.79, 34.97)	0.947
2007	0.09	(34.65, 35.02)	(34.67, 34.97)	(34.70, 34.93)	(34.72, 34.90)	(34.74, 34.88)	0.969
2008	0.15	(34.57, 35.17)	(34.62, 35.10)	(34.67, 35.03)	(34.70, 34.98)	(34.73, 34.95)	0.982

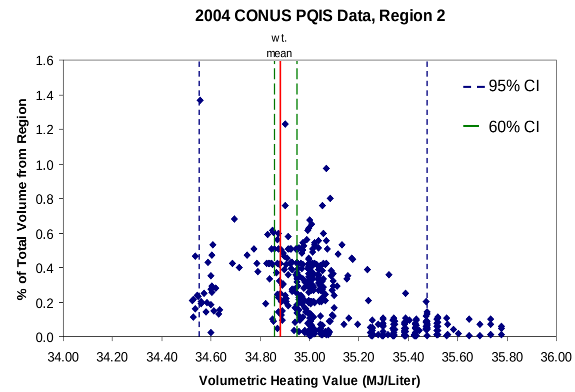


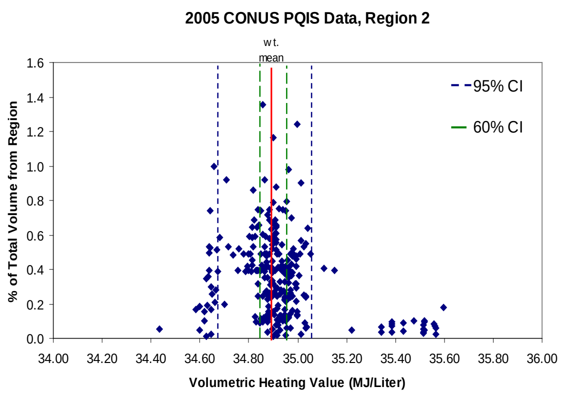


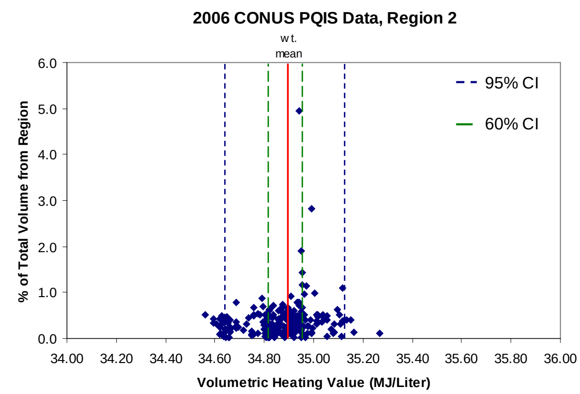

2001 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

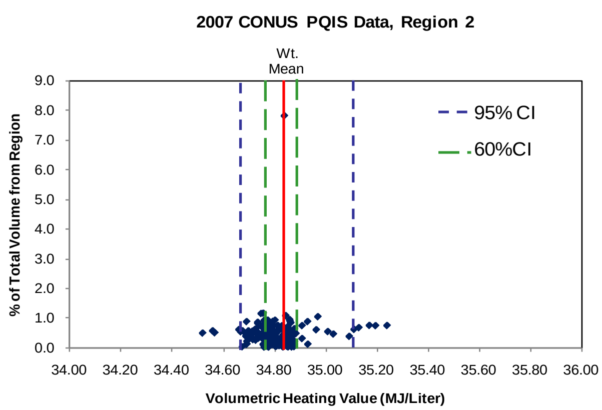

2002 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

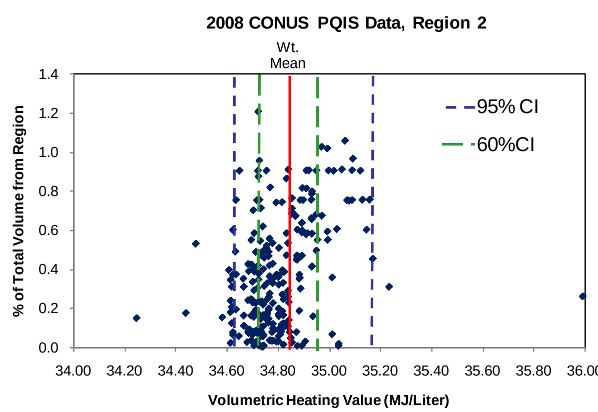

2003 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2004 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2005 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2006 CONUS PQIS Data, Region 2
wt. mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2007 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

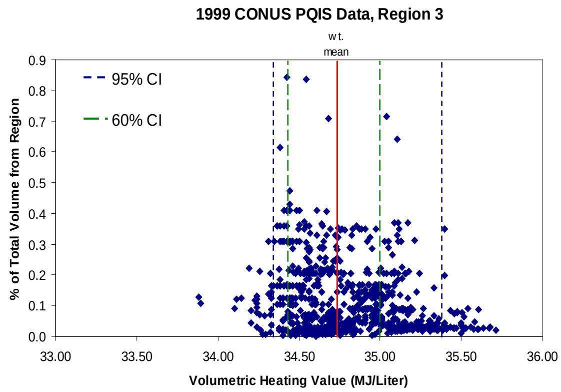

2008 CONUS PQIS Data, Region 2
Wt. Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

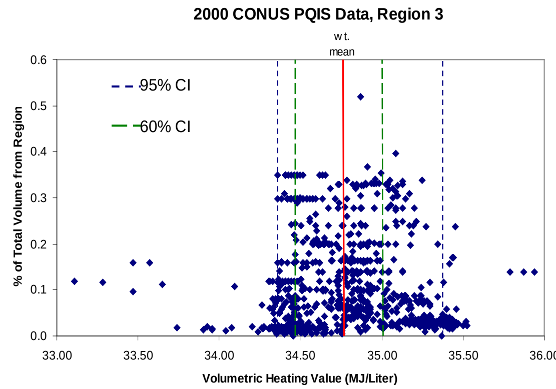
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 3 Based on PQIS Data from 1999-2008.

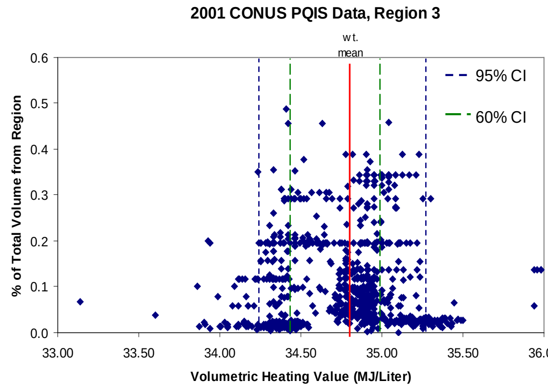
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	34.73	0.31	(34.34, 35.34)	(34.37, 35.21)	(34.39, 35.13)	(34.44, 35.05)	(34.44, 35.00)
2000	34.76	0.36	(34.37, 35.37)	(34.39, 35.26)	(34.42, 35.16)	(34.44, 35.10)	(34.47, 35.00)
2001	34.79	0.36	(34.23, 35.26)	(34.29, 35.18)	(34.34, 35.10)	(34.39, 35.02)	(34.44, 35.00)
2002	34.87	0.35	(34.21, 35.29)	(34.31, 35.21)	(34.42, 35.18)	(34.63, 35.13)	(34.71, 35.10)
2003	34.84	0.37	(34.26, 35.24)	(34.31, 35.18)	(34.39, 35.13)	(34.52, 35.10)	(34.66, 35.02)
2004	34.68	0.38	(34.21, 35.29)	(34.23, 35.21)	(34.26, 35.10)	(34.29, 35.02)	(34.31, 34.97)
2005	34.76	0.39	(34.23, 35.53)	(34.29, 35.18)	(34.31, 35.10)	(34.34, 35.02)	(34.44, 35.00)
2006	34.79	0.35	(34.23, 35.18)	(34.29, 35.13)	(34.39, 35.10)	(34.47, 35.02)	(34.58, 34.97)
2007	34.75	0.31	(34.25, 35.15)	(34.28, 35.08)	(34.34, 35.02)	(34.40, 34.96)	(34.51, 34.95)
2008	34.71	0.27	(34.28, 35.03)	(34.34, 34.99)	(34.38, 34.95)	(34.42, 34.91)	(34.49, 34.90)

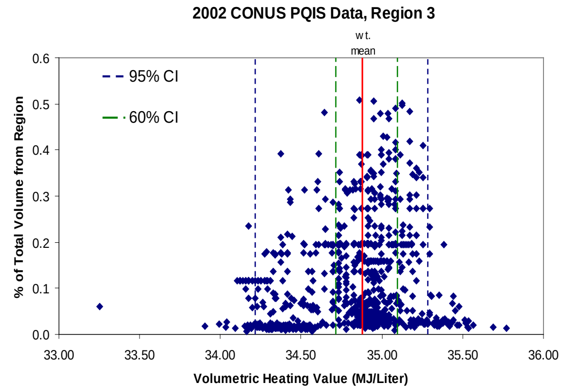
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 3 Based on the Lognormal Distribution of PQIS Data from 1999-2008.

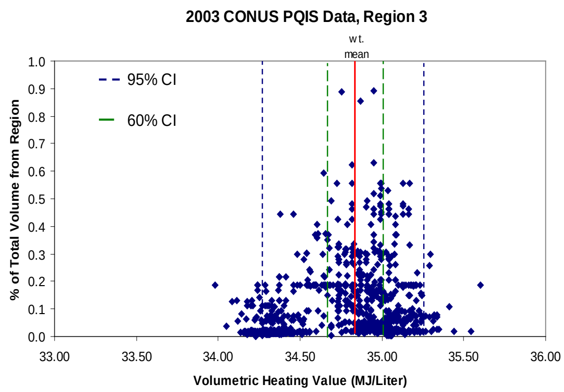
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.28	(34.26, 35.34)	(34.31, 35.24)	(34.39, 35.10)	(34.44, 35.00)	(34.47, 34.95)	0.988
2000	0.30	(34.18, 35.34)	(34.29, 35.26)	(34.37, 35.16)	(34.44, 35.05)	(34.50, 35.00)	0.976
2001	0.32	(34.21, 35.45)	(34.29, 35.34)	(34.39, 35.21)	(34.44, 35.13)	(34.50, 35.00)	0.955
2002	0.26	(34.34, 35.37)	(34.42, 35.29)	(34.52, 35.21)	(34.58, 35.16)	(34.66, 35.10)	0.970
2003	0.25	(34.34, 35.34)	(34.42, 35.26)	(34.50, 35.18)	(34.55, 35.10)	(34.63, 35.02)	0.978
2004	0.34	(34.07, 35.39)	(34.18, 35.26)	(34.26, 35.13)	(34.34, 35.00)	(34.37, 34.92)	0.968
2005	0.33	(34.23, 35.50)	(34.29, 35.34)	(34.37, 35.18)	(34.42, 35.10)	(34.47, 35.00)	0.978
2006	0.25	(34.23, 35.24)	(34.34, 35.18)	(34.44, 35.10)	(34.50, 35.02)	(34.58, 35.00)	0.989
2007	0.24	(34.71, 34.81)	(34.72, 34.80)	(34.73, 34.79)	(34.73, 34.78)	(34.74, 34.78)	0.986
2008	0.21	(34.29, 35.13)	(34.36, 35.06)	(34.43, 34.98)	(34.49, 34.93)	(34.53, 34.89)	0.981

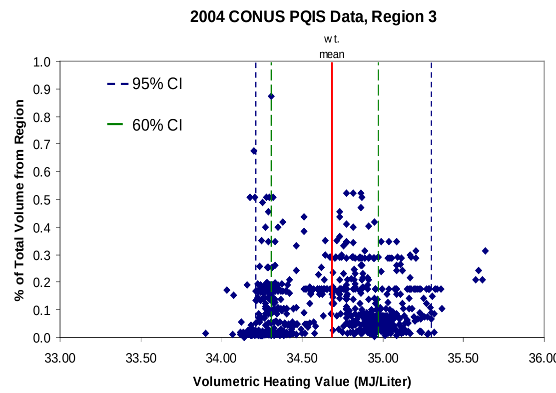


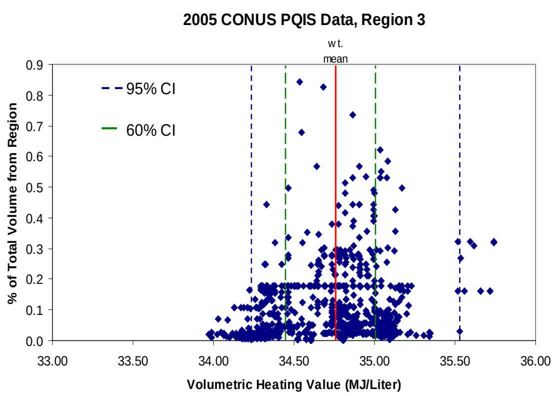


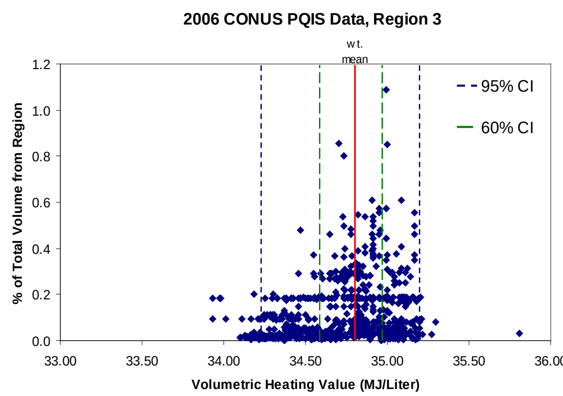

2001 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

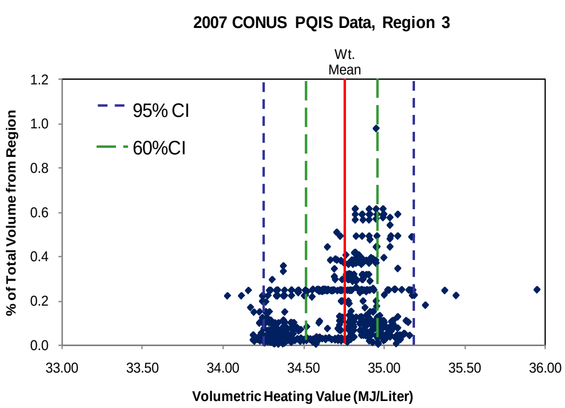

2002 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

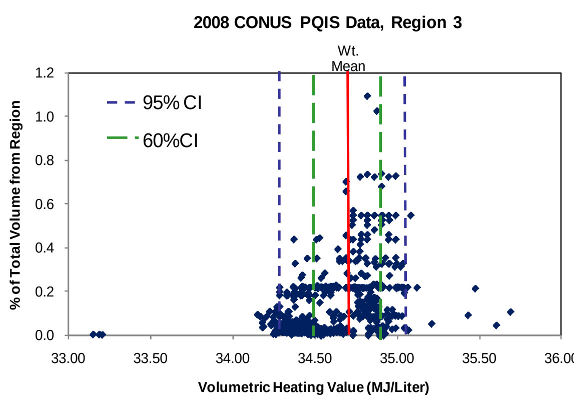

2003 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2004 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2005 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2006 CONUS PQIS Data, Region 3
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2007 CONUS PQIS Data, Region 3
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

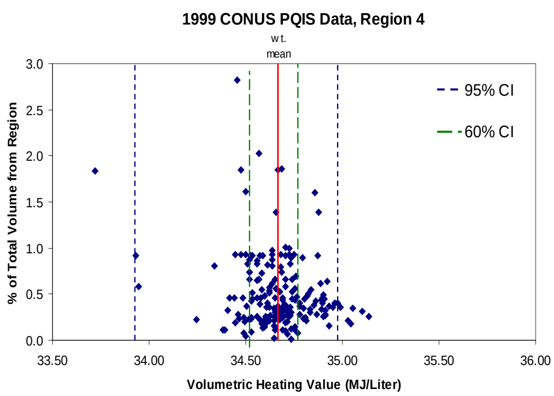

2008 CONUS PQIS Data, Region 3
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

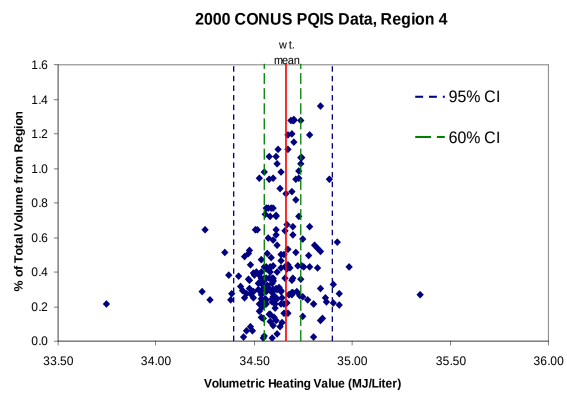
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 4 Based on PQIS Data from 1999-2008.

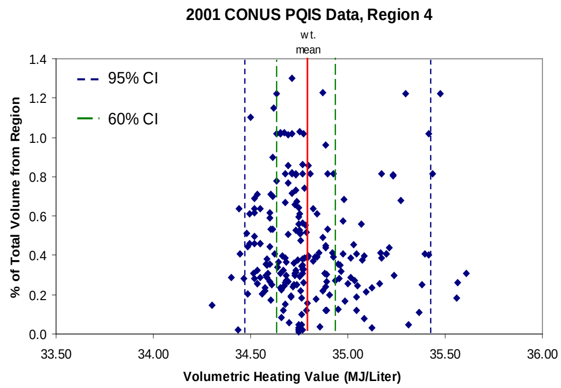
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	34.66	0.21	(33.92, 34.97)	(34.42, 34.92)	(34.44, 34.87)	(34.50, 34.84)	(34.52, 34.76)
2000	34.66	0.14	(34.39, 34.89)	(34.47, 34.84)	(34.50, 34.79)	(34.52, 34.73)	(34.55, 34.73)
2001	34.79	0.24	(34.47, 35.42)	(34.50, 35.37)	(34.52, 35.21)	(34.58, 35.02)	(34.63, 34.92)
2002	34.89	0.38	(34.42, 35.71)	(34.44, 35.68)	(34.50, 35.55)	(34.55, 35.42)	(34.55, 35.34)
2003	34.71	0.23	(34.42, 35.21)	(34.44, 35.16)	(34.50, 34.89)	(34.50, 34.84)	(34.55, 34.79)
2004	34.71	0.24	(34.44, 35.47)	(34.50, 35.24)	(34.52, 34.87)	(34.55, 34.81)	(34.55, 34.79)
2005	34.73	0.30	(34.39, 35.37)	(34.42, 35.34)	(34.44, 35.21)	(34.44, 34.97)	(34.47, 34.92)
2006	34.73	0.34	(34.39, 35.45)	(34.39, 35.34)	(34.42, 35.29)	(34.44, 35.21)	(34.44, 35.05)
2007	34.86	0.40	(34.34, 35.58)	(34.36, 35.56)	(34.40, 35.52)	(34.40, 35.48)	(34.46, 35.42)
2008	34.76	0.29	(34.42, 35.29)	(34.46, 35.25)	(34.48, 35.11)	(34.50, 35.09)	(34.52, 34.99)

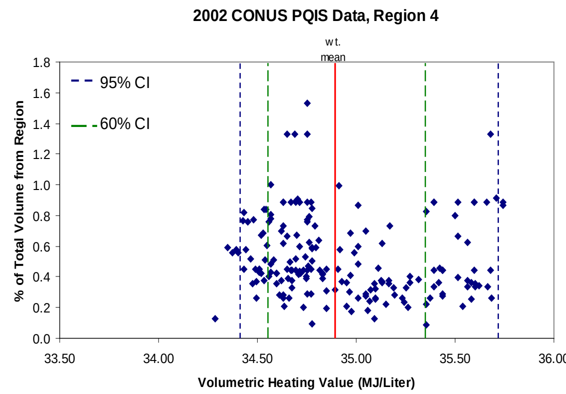
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 4 Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

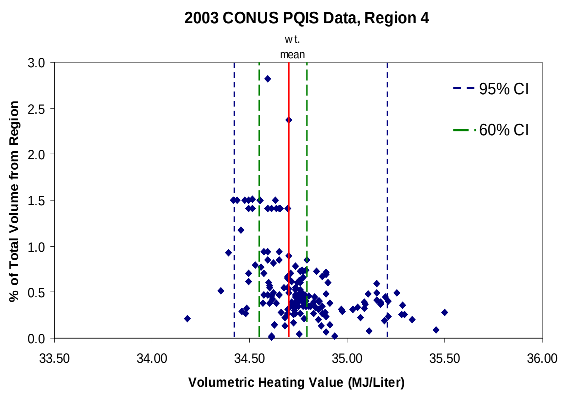
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.21	(34.21, 35.05)	(34.29, 34.97)	(34.37, 34.89)	(34.42, 34.84)	(34.47, 34.81)	0.923
2000	0.13	(34.37, 34.89)	(34.42, 34.84)	(34.47, 34.79)	(34.50, 34.76)	(34.52, 34.73)	0.978
2001	0.25	(34.47, 35.39)	(34.50, 35.24)	(34.55, 35.05)	(34.58, 34.97)	(34.63, 34.92)	0.987
2002	0.54	(34.42, 36.11)	(34.44, 35.71)	(34.50, 35.39)	(34.55, 35.24)	(34.58, 35.13)	0.972
2003	0.19	(34.39, 35.16)	(34.44, 35.02)	(34.50, 34.92)	(34.52, 34.87)	(34.55, 34.81)	0.989
2004	0.18	(34.42, 35.13)	(34.44, 35.00)	(34.50, 34.89)	(34.52, 34.84)	(34.55, 34.81)	0.964
2005	0.49	(34.39, 35.63)	(34.42, 35.32)	(34.44, 35.05)	(34.47, 34.92)	(34.50, 34.84)	0.979
2006	-	(34.39, 36.21)	(34.42, 35.55)	(34.44, 35.16)	(34.44, 34.97)	(34.47, 34.87)	0.956
2007	1.38	(34.35, 36.56)	(34.38, 35.92)	(34.43, 35.44)	(34.46, 35.21)	(34.50, 35.07)	0.950
2008	0.37	(34.42, 35.59)	(34.45, 35.32)	(34.49, 35.10)	(34.52, 34.99)	(34.55, 34.91)	0.968

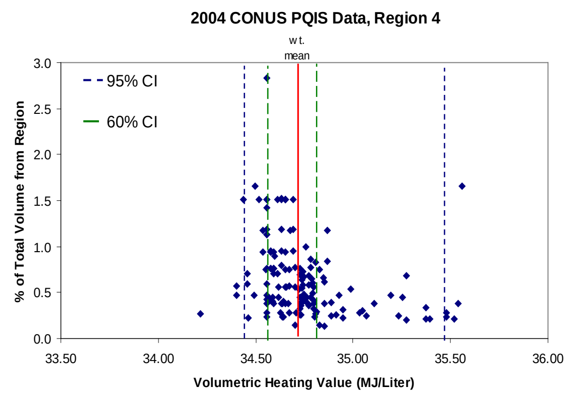


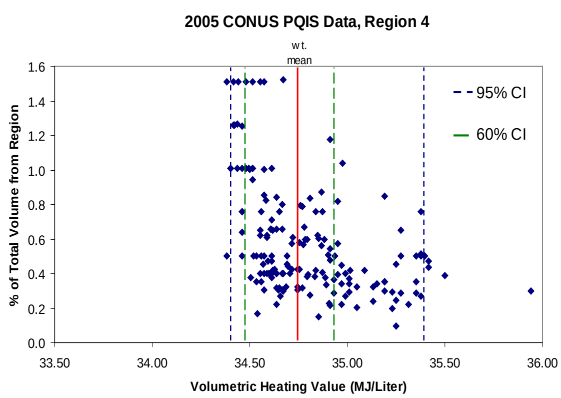


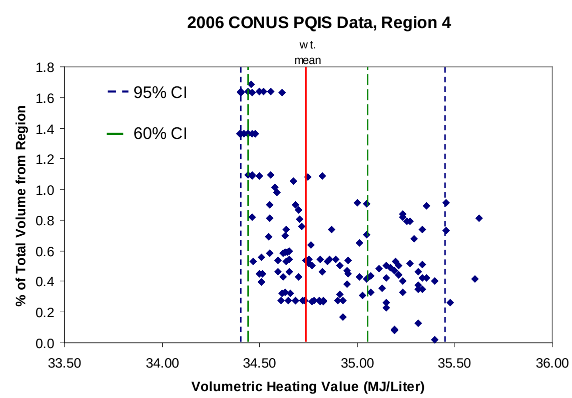

2001 CONUS PQIS Data, Region 4
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
33.50
34.00
34.50
35.00
35.50
36.00

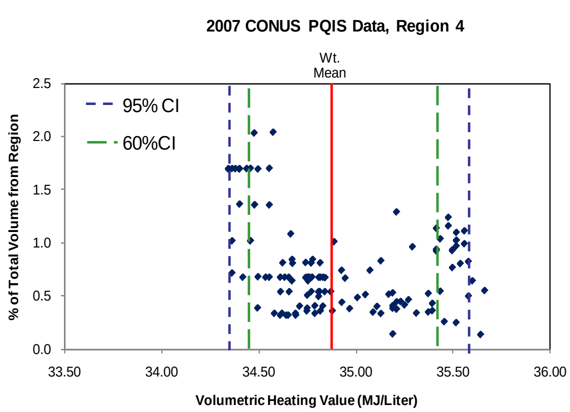

2002 CONUS PQIS Data, Region 4
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
33.50
34.00
34.50
35.00
35.50
36.00

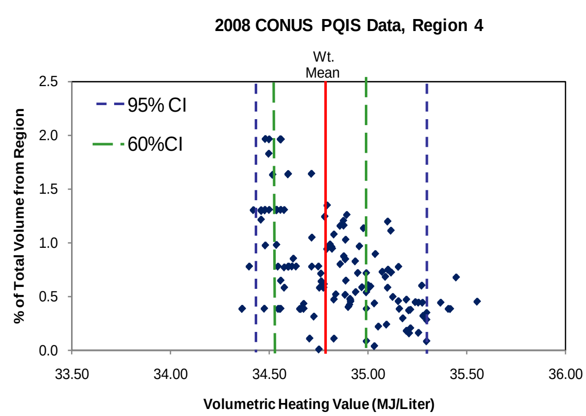

2003 CONUS PQIS Data, Region 4
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
33.50
34.00
34.50
35.00
35.50
36.00


2004 CONUS PQIS Data, Region 4
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
33.50
34.00
34.50
35.00
35.50
36.00


2005 CONUS PQIS Data, Region 4
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
33.50
34.00
34.50
35.00
35.50
36.00


2006 CONUS PQIS Data, Region 4
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
33.50
34.00
34.50
35.00
35.50
36.00


2007 CONUS PQIS Data, Region 4
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.5
1.0
1.5
2.0
2.5
33.50
34.00
34.50
35.00
35.50
36.00

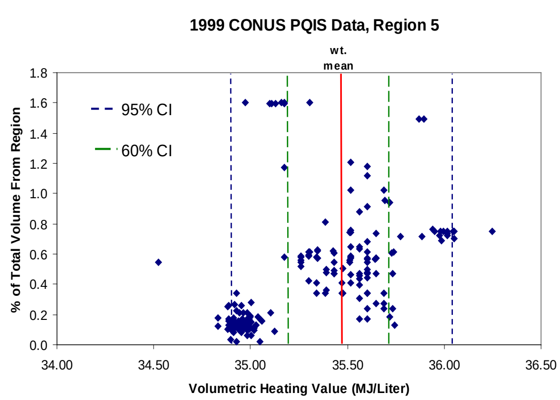

2008 CONUS PQIS Data, Region 4
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)
0.0
0.5
1.0
1.5
2.0
2.5
33.50
34.00
34.50
35.00
35.50
36.00

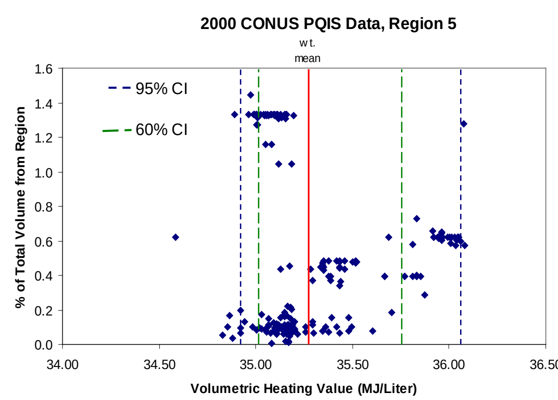
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 5 Based on PQIS Data from 1999-2008.

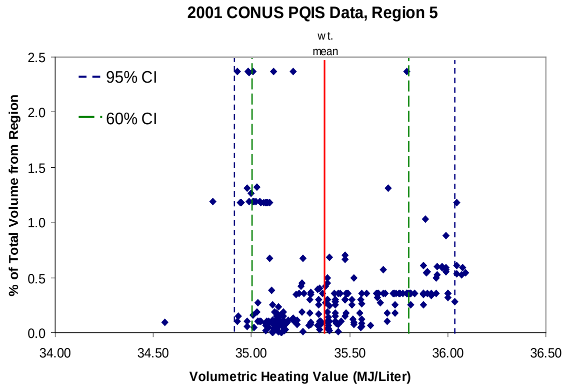
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	35.45	0.38	(34.89, 36.03)	(34.95, 36.00)	(34.97, 35.95)	(35.10, 35.79)	(35.18, 35.71)
2000	35.29	0.40	(34.92, 36.05)	(34.97, 36.03)	(35.00, 35.95)	(35.00, 35.92)	(35.02, 35.76)
2001	35.37	0.31	(34.92, 36.03)	(34.95, 36.00)	(34.97, 35.95)	(34.97, 35.87)	(35.00, 35.79)
2002	35.47	0.32	(34.95, 35.98)	(34.97, 35.98)	(34.97, 35.90)	(35.00, 35.82)	(35.02, 35.76)
2003	35.45	0.33	(34.87, 36.00)	(34.89, 35.98)	(34.92, 35.95)	(34.95, 35.90)	(35.00, 35.87)
2004	35.50	0.32	(34.79, 35.98)	(34.84, 35.98)	(34.92, 35.92)	(34.97, 35.90)	(35.05, 35.87)
2005	35.29	0.29	(34.81, 35.87)	(34.84, 35.82)	(34.92, 35.76)	(34.95, 35.74)	(34.97, 35.68)
2006	35.26	0.25	(34.81, 35.79)	(34.87, 35.71)	(34.95, 35.66)	(34.97, 35.61)	(35.00, 35.61)
2007	35.33	0.36	(34.94, 35.99)	(34.95, 35.95)	(34.97, 35.91)	(34.99, 35.82)	(35.01, 35.74)
2008	35.32	0.29	(34.93, 35.91)	(34.99, 35.86)	(35.05, 35.78)	(35.07, 35.78)	(35.08, 35.69)

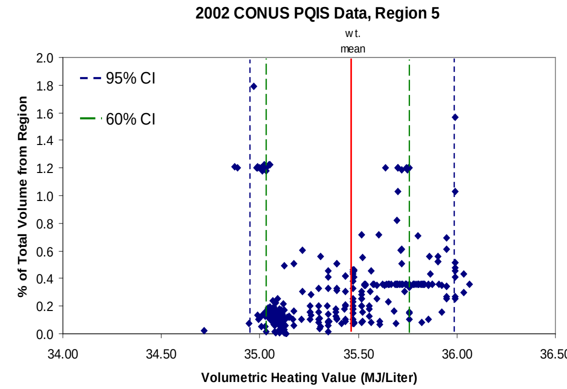
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from Region 5 Based on the Lognormal Distribution of PQIS Data from 1999-2008.

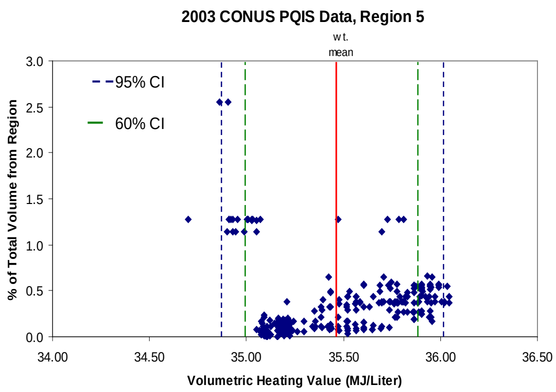
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.33	(34.81, 36.11)	(34.92, 35.98)	(35.02, 35.87)	(35.13, 35.79)	(35.18, 35.74)	0.990
2000	0.32	(34.81, 36.03)	(34.87, 35.87)	(34.92, 35.71)	(34.97, 35.61)	(35.02, 35.50)	0.931
2001	0.38	(34.84, 36.29)	(34.89, 36.05)	(34.95, 35.87)	(35.00, 35.74)	(35.05, 35.66)	0.962
2002	0.33	(34.81, 36.13)	(34.92, 36.00)	(35.02, 35.90)	(35.13, 35.82)	(35.21, 35.76)	0.956
2003	0.38	(34.73, 36.21)	(34.84, 36.11)	(34.97, 35.95)	(35.05, 35.84)	(35.16, 35.76)	0.949
2004	0.37	(34.76, 36.24)	(34.89, 36.11)	(35.02, 35.98)	(35.13, 35.87)	(35.18, 35.82)	0.952
2005	0.33	(34.79, 36.00)	(34.79, 35.87)	(34.89, 35.74)	(34.95, 35.63)	(35.00, 35.55)	0.979
2006	0.26	(34.73, 35.79)	(34.81, 35.68)	(34.89, 35.61)	(34.97, 35.53)	(35.02, 35.47)	0.967
2007	0.37	(34.87, 36.28)	(34.90, 36.03)	(34.95, 35.79)	(34.99, 35.65)	(35.03, 35.55)	0.952
2008	0.34	(34.95, 36.20)	(34.98, 35.95)	(35.01, 35.72)	(35.04, 35.59)	(35.07, 35.50)	0.959

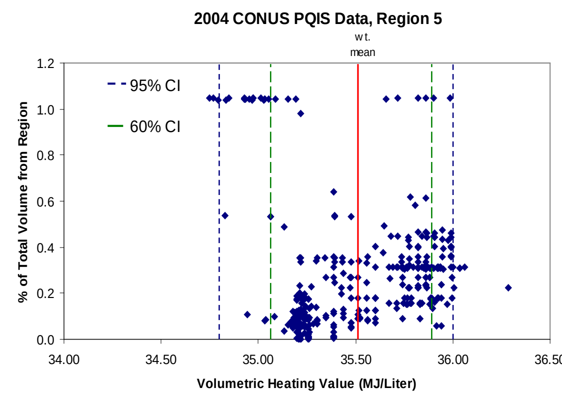


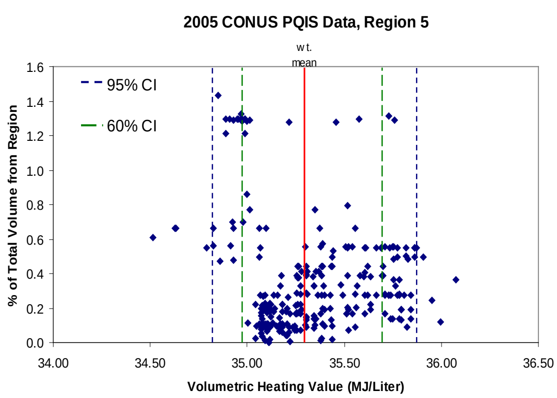


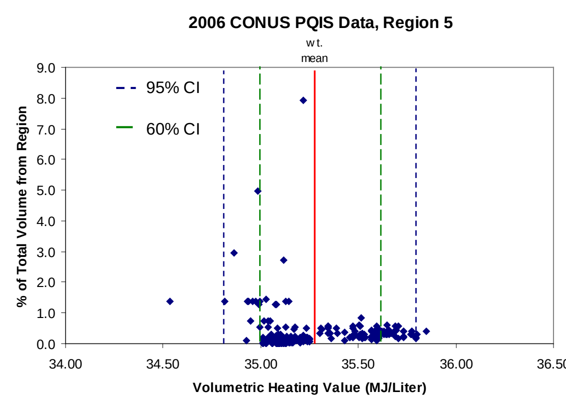

2001 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

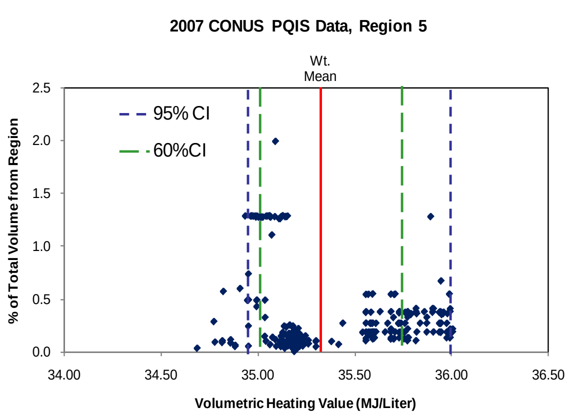

2002 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

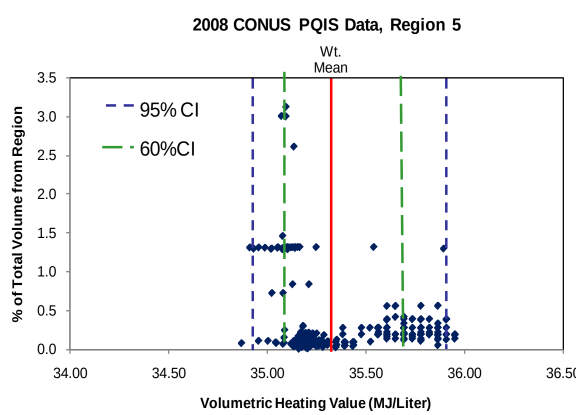

2003 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2004 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2005 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2006 CONUS PQIS Data, Region 5
wt.
mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)


2007 CONUS PQIS Data, Region 5
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

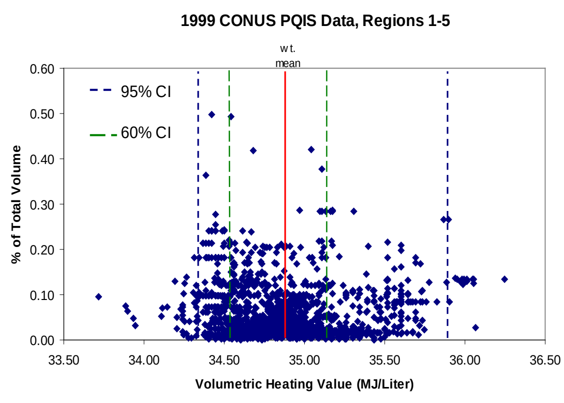

2008 CONUS PQIS Data, Region 5
Wt.
Mean
95% CI
60%CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

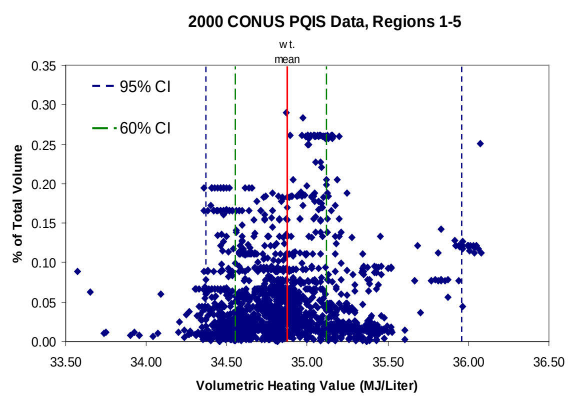
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from CONUS Based on PQIS Data from 1999-2008.

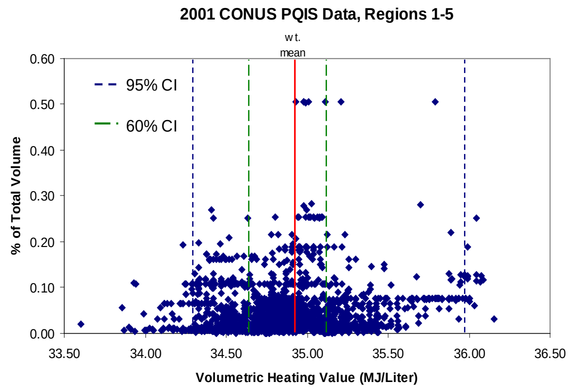
Year	Wt mean	Stdev	95% CI	90% CI	80% CI	70% CI	60% CI
1999	34.87	0.34	(34.34, 35.87)	(34.39, 35.66)	(34.44, 35.45)	(34.47, 35.26)	(34.52, 35.13)
2000	34.87	0.36	(34.37, 35.95)	(34.42, 35.47)	(34.47, 35.26)	(34.50, 35.16)	(34.55, 35.10)
2001	34.92	0.38	(34.29, 35.95)	(34.34, 35.79)	(34.42, 35.42)	(34.50, 35.24)	(34.63, 35.10)
2002	35.00	0.39	(34.29, 35.90)	(34.39, 35.76)	(34.55, 35.66)	(34.71, 35.39)	(34.71, 35.21)
2003	34.97	0.42	(34.29, 35.92)	(34.37, 35.87)	(34.52, 35.61)	(34.63, 35.24)	(34.71, 35.16)
2004	34.89	0.50	(34.21, 35.92)	(34.26, 35.87)	(34.29, 35.74)	(34.31, 35.39)	(34.37, 35.24)
2005	34.87	0.42	(34.26, 35.76)	(34.31, 35.66)	(34.37, 35.39)	(34.47, 35.18)	(34.55, 35.10)
2006	34.89	0.38	(34.26, 35.63)	(34.34, 35.50)	(34.44, 35.24)	(34.55, 35.13)	(34.66, 35.10)
2007	34.91	0.42	(34.27, 35.94)	(34.33, 35.77)	(34.42, 35.54)	(34.59, 35.16)	(34.67, 35.09)
2008	34.87	0.40	(34.33, 35.78)	(34.37, 35.69)	(34.44, 35.25)	(34.53, 35.13)	(34.58, 35.09)

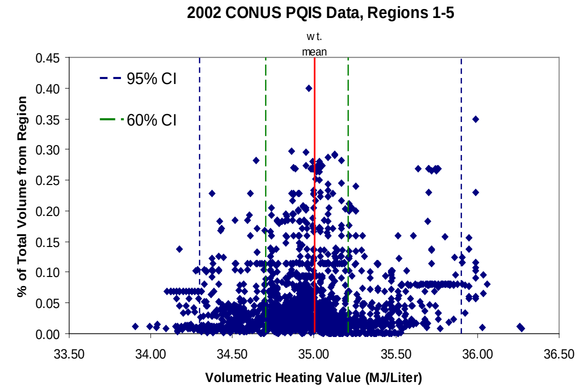
Statistics and Confidence Intervals for the Volumetric Heating Value (MJ/Liter) of JP-8 Fuel from CONUS Based on the Loglogistic Distribution of PQIS Data from 1999-2008.

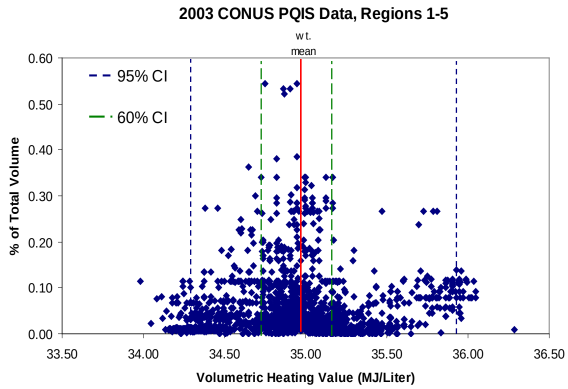
Year	Stdev	95% CI	90% CI	80% CI	70% CI	60%CI	Correlation
1999	0.39	(34.26, 35.76)	(34.34, 35.53)	(34.42, 35.32)	(34.50, 35.21)	(34.55, 35.13)	0.986
2000	0.36	(34.15, 35.61)	(34.29, 35.45)	(34.42, 35.32)	(34.52, 35.21)	(34.58, 35.16)	0.960
2001	0.40	(34.23, 35.82)	(34.34, 35.63)	(34.47, 35.39)	(34.55, 35.29)	(34.63, 35.21)	0.988
2002	0.38	(34.34, 35.84)	(34.44, 35.66)	(34.55, 35.47)	(34.66, 35.37)	(34.73, 35.29)	0.985
2003	0.39	(34.34, 35.87)	(34.42, 35.66)	(34.52, 35.42)	(34.63, 35.32)	(34.68, 35.24)	0.982
2004	0.49	(34.15, 36.03)	(34.26, 35.74)	(34.37, 35.47)	(34.44, 35.32)	(34.52, 35.24)	0.968
2005	0.38	(34.26, 35.76)	(34.34, 35.53)	(34.44, 35.34)	(34.52, 35.24)	(34.58, 35.16)	0.986
2006	0.31	(34.29, 35.55)	(34.39, 35.42)	(34.50, 35.26)	(34.58, 35.18)	(34.66, 35.13)	0.991
2007	0.38	(34.30, 35.78)	(34.39, 35.57)	(34.49, 35.36)	(34.56, 35.25)	(34.62, 35.16)	0.979
2008	0.34	(34.28, 35.64)	(34.38, 35.46)	(34.48, 35.29)	(34.55, 35.19)	(34.61, 35.11)	0.982

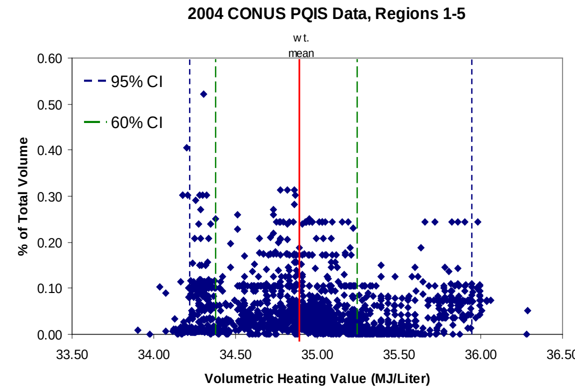


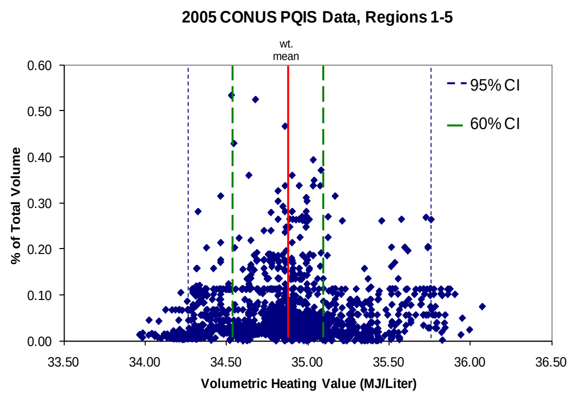


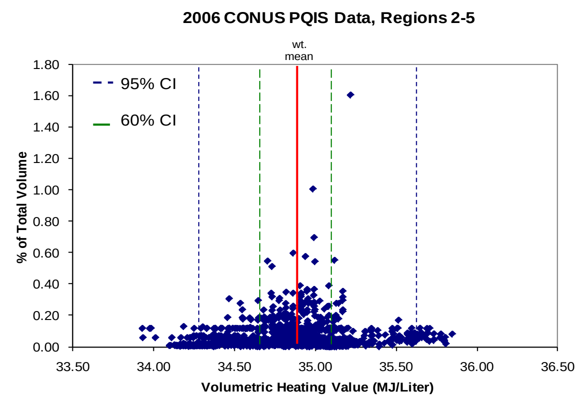

2001 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Volumetric Heating Value (MJ/Liter)

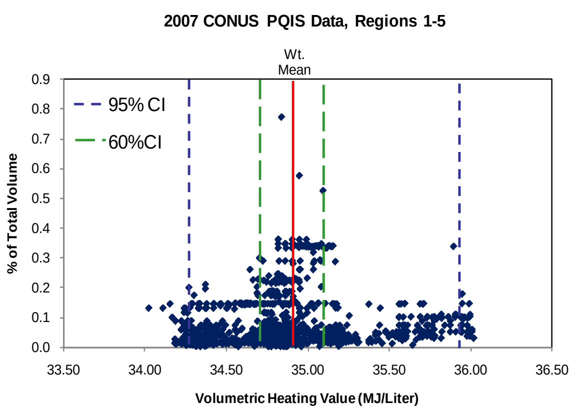

2002 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume from Region
Volumetric Heating Value (MJ/Liter)

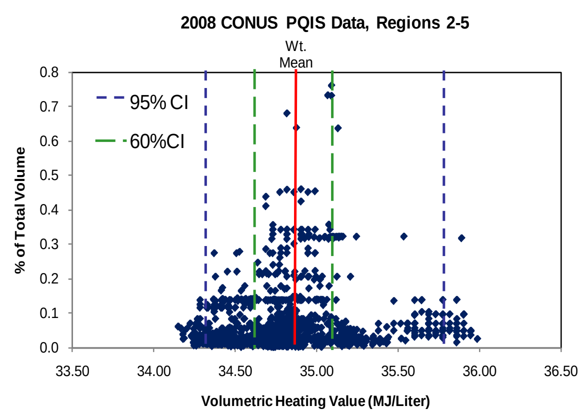

2003 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Volumetric Heating Value (MJ/Liter)


2004 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Volumetric Heating Value (MJ/Liter)

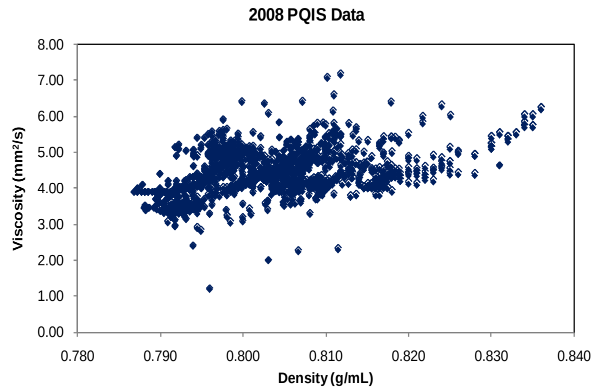

2005 CONUS PQIS Data, Regions 1-5
wt. mean
95% CI
60% CI
% of Total Volume
Volumetric Heating Value (MJ/Liter)

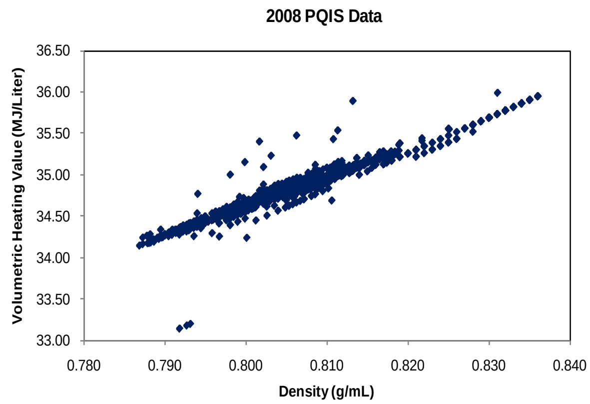

2006 CONUS PQIS Data, Regions 2-5
wt. mean
95% CI
60% CI
% of Total Volume
Volumetric Heating Value (MJ/Liter)

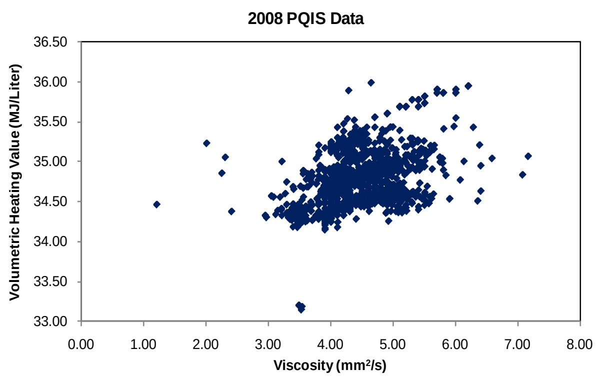

2007 CONUS PQIS Data, Regions 1-5
Wt. Mean
95% CI
60%CI
% of Total Volume
Volumetric Heating Value (MJ/Liter)


2008 CONUS PQIS Data, Regions 2-5
Wt. Mean
95% CI
60%CI
% of Total Volume
Volumetric Heating Value (MJ/Liter)

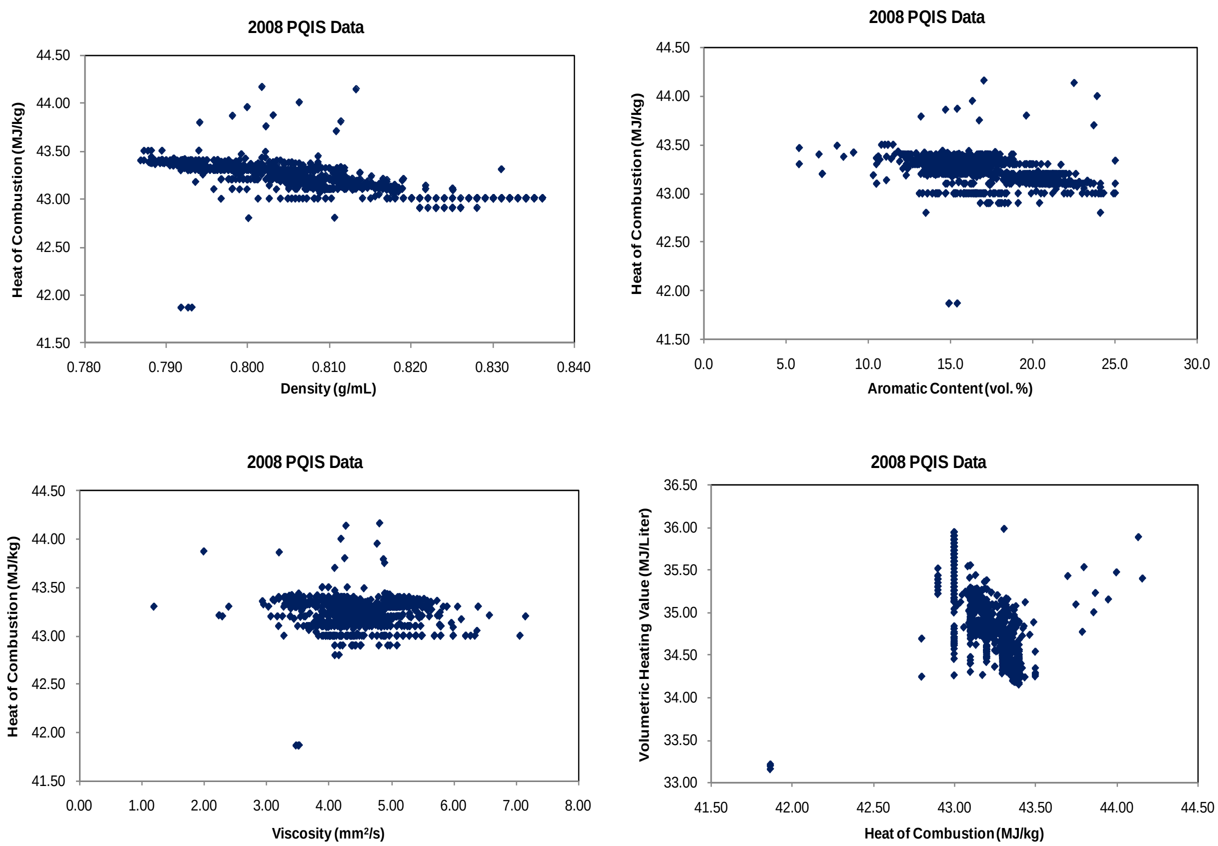
7.7 Property Correlations



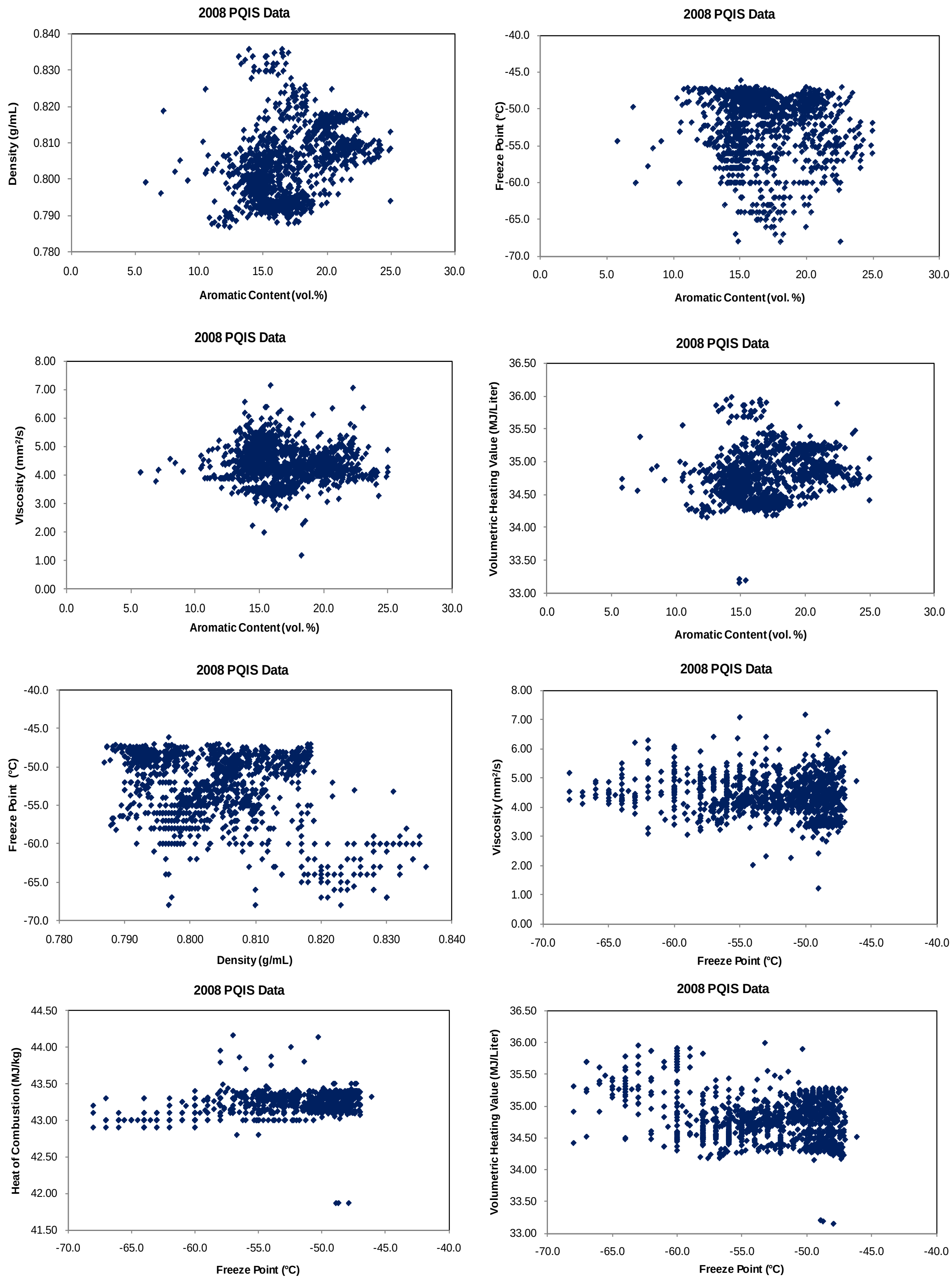




Plot of JP-8 Property Comparisons with Positive Correlations Based on 2008 PQIS Data.



Plot of JP-8 Property Comparisons with Negative Correlations Based on 2008 PQIS Data.

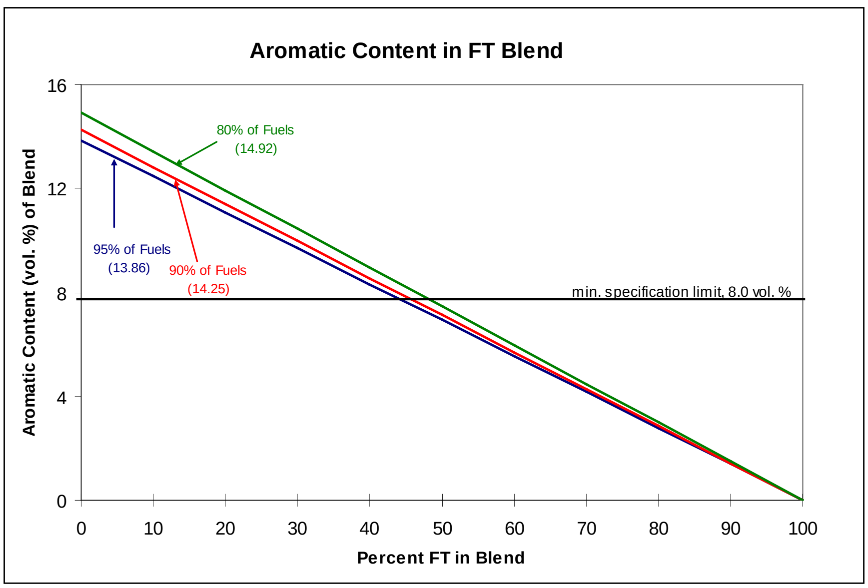


Plot of JP-8 Property Comparisons with Weak Correlations Based on 2008 PQIS Data.

7.8 Maximum Percentage of JP-8 in Blend With SPK

Maximum Percent of FT Fuel in Blend to Maintain Minimum 8.0 vol. % Aromatic Content Based on PQIS Data from Region 1.

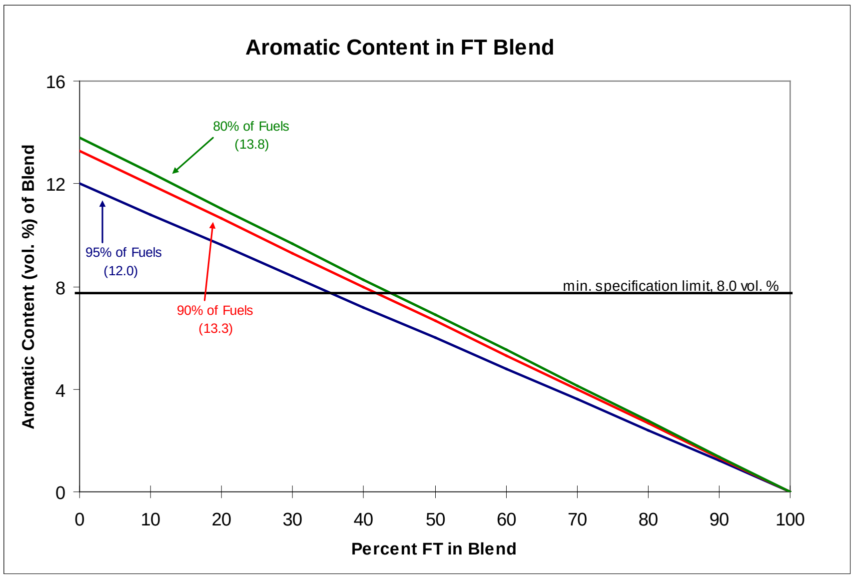
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Lognormal Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1997	39.4	39.8	45.7	41.2	43.0	44.9
1998	44.9	45.6	47.1	44.9	45.7	46.7
1999	42.3	43.9	46.4	41.1	43.6	46.2
2000	43.5	45.4	46.6	43.4	44.7	46.2
2001	40.2	40.2	44.5	41.1	42.2	43.6
2002	57.7	58.5	58.8	57.2	58.0	58.9
2003	53.8	55.6	57.2	55.2	56.3	57.5
2004	20.8	40.7	53.2	45.4	48.7	52.0
2005	54.3	54.3	54.3	52.1	53.1	54.1
2007	52.9	52.9	55.1	53.8	54.3	54.8
2008	33.9	33.9	33.9	45.2	47.0	49.0



FT Fuel Blending Affect on Aromatic Content Based on JP-8 Statistics from 1999 in Region 1.

Maximum Percent of FT Fuel in Blend to Maintain Minimum 8.0 vol. % Aromatic Content Based on PQIS Data from Region 2.

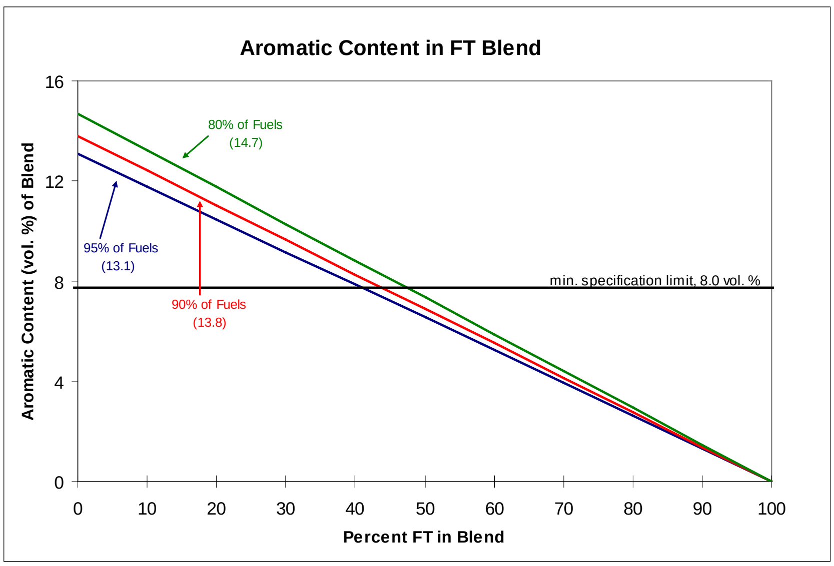
Year	Based on PQIS Data 95% Confidence	Based on PQIS Data 90% Confidence	Based on PQIS Data 80% Confidence	Based on Loglogistic Distribution of PQIS Data 95% Confidence	Based on Loglogistic Distribution of PQIS Data 90% Confidence	Based on Loglogistic Distribution of PQIS Data 80% Confidence
1997	12.1	29.2	36.0	24.5	29.5	34.0
1998	0.0	0.0	31.6	5.0	17.1	26.9
1999	33.3	39.8	42.0	33.4	36.0	38.7
2000	38.0	38.5	40.7	37.3	38.7	40.3
2001	31.6	35.5	38.9	30.8	34.0	37.4
2002	35.5	37.5	39.8	32.3	35.5	38.6
2003	20.8	32.8	39.4	27.2	31.8	36.0
2004	24.5	28.6	35.0	25.6	30.4	34.8
2005	29.2	33.9	38.0	32.4	35.1	37.8
2006	27.3	34.4	39.8	29.6	33.3	36.8
2007	31.6	32.8	36.0	31.6	33.9	37.0
2008	23.8	35.0	38.5	27.9	32.8	36.5



FT Fuel Blending Affect on Aromatic Content Based on JP-8 Statistics from 1999 in Region 2.

Maximum Percent of FT Fuel in Blend to Maintain Minimum 8.0 vol. % Aromatic Content Based on PQIS Data from Region 3.

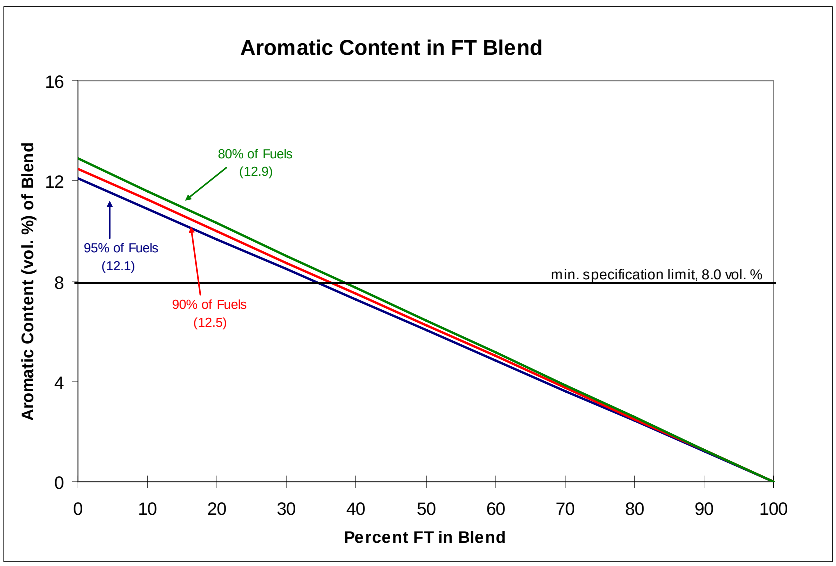
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Weibull Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1997	35.5	38.9	42.9	32.8	39.1	45.0
1998	39.4	41.2	44.4	38.5	42.1	46.0
1999	38.9	42.0	45.6	38.6	42.7	46.6
2000	40.3	42.9	49.4	42.2	464	50.3
2001	38.0	41.2	48.7	38.4	43.7	48.6
2002	36.5	42.4	48.7	39.2	45.1	50.3
2003	36.5	39.4	47.4	34.5	41.4	47.4
2004	37.0	40.3	45.9	32.6	40.0	46.2
2005	36.5	39.4	47.0	32.8	40.6	46.9
2006	38.0	38.9	42.4	31.6	37.9	43.9
2007	37.0	38.9	45.2	36.5	40.3	44.8
2008	35.5	43.3	45.9	37.0	40.7	45.2



FT Fuel Blending Affect on Aromatic Content Based on JP-8 Statistics from 1999 in Region 3.

Maximum Percent of FT Fuel in Blend to Maintain Minimum 8.0 vol. % Aromatic Content Based on PQIS Data from Region 4.

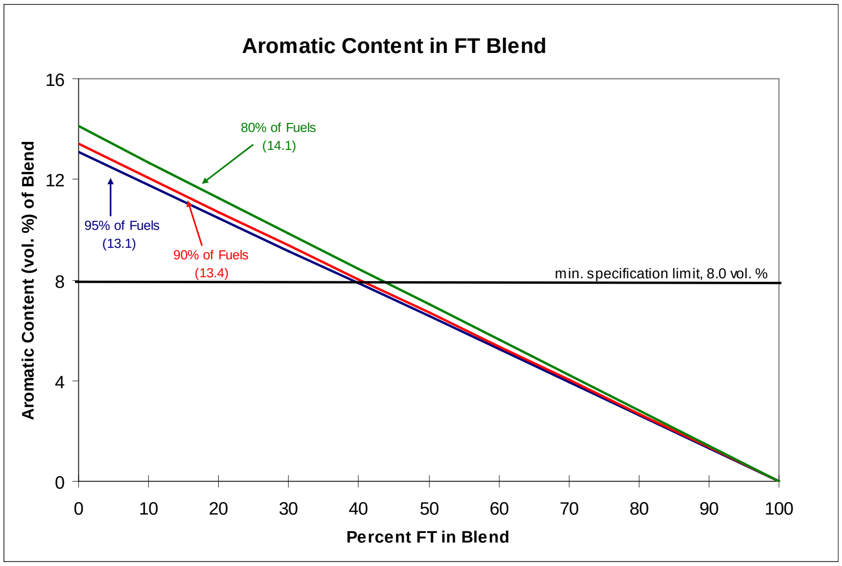
Year	Based on PQIS Data 95% Confidence	Based on PQIS Data 90% Confidence	Based on PQIS Data 80% Confidence	Based on Lognormal Distribution of PQIS Data 95% Confidence	Based on Lognormal Distribution of PQIS Data 90% Confidence	Based on Lognormal Distribution of PQIS Data 80% Confidence
1997	39.4	39.8	42.0	39.5	40.9	42.5
1998	34.4	38.0	40.7	36.6	38.3	40.3
1999	33.9	36.0	38.0	32.7	35.6	38.8
2000	23.1	29.2	33.9	19.7	25.1	30.7
2001	9.1	24.5	34.4	17.8	24.7	31.5
2002	36.5	38.5	42.9	34.5	38.1	42.1
2003	36.0	44.4	45.9	37.9	40.2	42.9
2004	41.2	43.3	45.6	40.2	42.1	44.4
2005	34.4	35.5	38.5	32.9	35.0	37.8
2006	33.9	38.5	40.7	20.9	28.4	35.4
2007	38.5	39.4	40.7	31.6	36.5	41.2
2008	5.9	27.9	37.0	17.5	23.8	31.0



FT Fuel Blending Affect on Aromatic Content Based on JP-8 Statistics from 1999 in Region 4.

Maximum Percent of FT Fuel in Blend to Maintain Minimum 8.0 vol. % Aromatic Content Based on PQIS Data from Region 5.

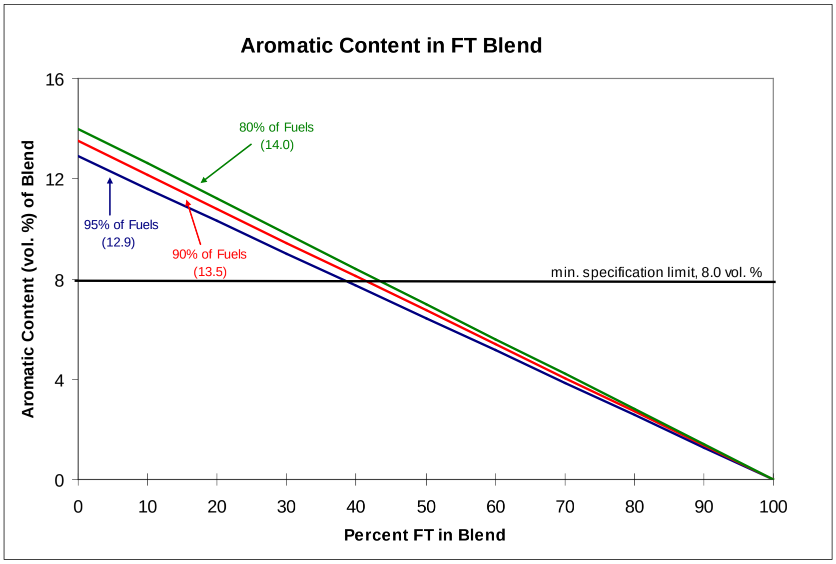
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Weibull Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1997	27.9	32.2	36.0	30.5	34.6154	39.5
1998	24.5	29.2	39.4	26.8	32.8668	39.1
1999	38.9	40.3	43.3	37.1	41.6	46.0
2000	34.9	39.8	41.2	36.2	40.4	44.6
2001	1.2	18.4	30.4	7.2	23.4	35.0
2002	14.0	18.4	23.8	7.7	23.6	35.1
2003	16.7	24.5	29.8	17.1	28.6	38.0
2004	31.6	38.0	41.2	32.0	36.0	40.3
2005	16.7	20.8	27.3	13.3	25.7	35.3
2006	46.3	48.7	50.3	46.9	48.9	51.0
2007	48.4	50.0	52.1	48.7	50.3	52.1
2008	41.2	43.7	47.7	39.8	44.8	49.4



FT Fuel Blending Affect on Aromatic Content Based on JP-8 Statistics from 1999 in Region 5.

Maximum Percent of FT Fuel in Blend to Maintain Minimum 8.0 vol. % Aromatic Content Based on PQIS Data from CONUS.

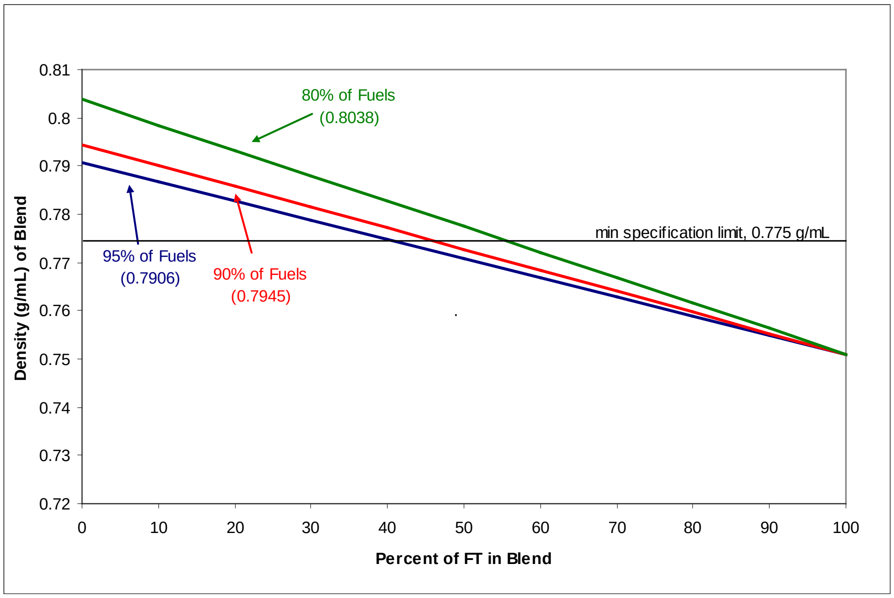
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Weibull Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1997	32.2	35.5	40.3	26.6	33.5	40.1
1998	29.2	39.4	42.4	24.3	32.9	40.5
1999	38.0	40.7	42.9	35.3	39.6	43.8
2000	38.0	40.3	42.4	34.3	39.3	44.2
2001	25.9	35.0	40.3	23.6	32.6	40.6
2002	25.2	33.9	41.6	22.1	33.4	42.4
2003	27.3	36.5	42.0	23.6	33.4	41.6
2004	32.8	37.5	42.4	26.9	34.6	41.4
2005	23.8	35.0	41.2	23.8	32.7	40.4
2006	37.0	38.9	42.9	27.5	35.5	42.5
2007	33.9	38.9	43.3	35.5	39.4	43.7
2008	34.9	40.3	44.1	31.0	37.5	43.3



FT Fuel Blending Affect on Aromatic Content Based on JP-8 Statistics from 1999 in Regions 1-5.

Maximum Percent of FT Fuel with Density of 0.751 g/mL in Blend to Maintain Minimum Density of 0.775 g/mL Based on PQIS Data from Region 1.

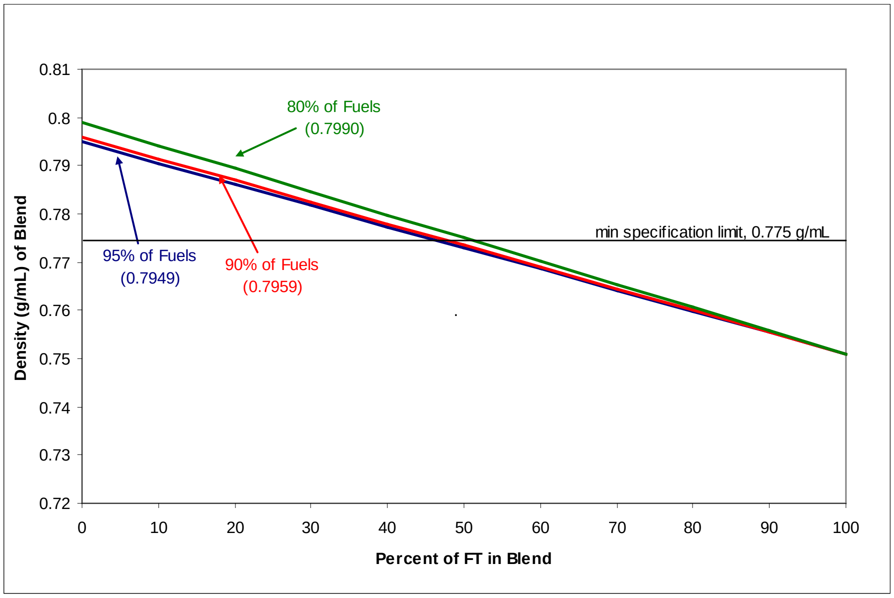
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Lognormal Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1999	41.5	42.9	45.5	42.9	44.2	46.7
2000	47.8	47.8	48.9	47.8	48.9	50.0
2001	48.9	50.0	51.0	48.9	50.0	51.0
2002	59.3	59.3	60.0	58.6	59.3	60.0
2003	54.7	55.6	60.7	53.8	55.6	57.1
2004	40.0	45.5	54.7	51.0	53.8	56.4
2005	42.9	42.9	42.9	40.0	40.0	41.5
2007	41.5	41.5	41.5	40.0	40.0	41.5
2008	42.9	42.9	42.9	-	-	-



FT Fuel Blending Affects on Density Based on JP-8 Statistics from 2004 in Region 1.

Maximum Percent of FT Fuel with Density of 0.751 g/mL in Blend to Maintain Minimum Density of 0.775 g/mL Based on PQIS Data from Region 2.

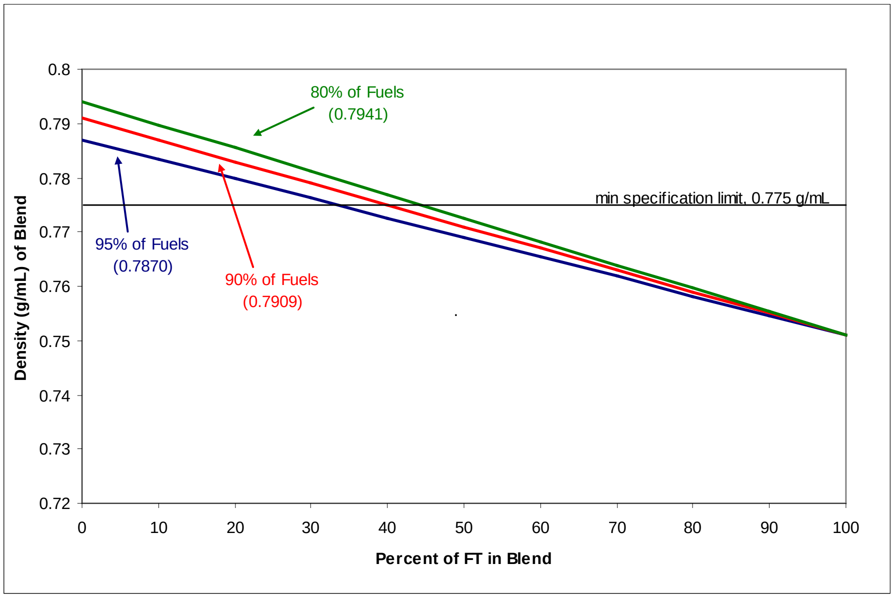
Year	Based on PQIS Data			Based on Loglogistic Distribution of PQIS Data		
	95% Confidence	90% Confidence	80% Confidence	95% Confidence	90% Confidence	80% Confidence
1999	52.9	53.8	53.8	50.0	51.0	52.9
2000	52.0	52.9	53.8	50.0	51.0	52.0
2001	46.7	47.8	50.0	46.7	47.8	50.0
2002	45.5	46.7	52.0	47.8	50.0	51.0
2003	45.5	46.7	50.0	46.7	48.9	51.0
2004	50.0	50.0	52.0	50.0	52.0	52.9
2005	51.0	52.0	52.0	51.0	52.0	52.9
2006	51.0	52.0	52.9	51.0	52.0	52.9
2007	52.0	52.0	52.9	51.0	52.0	52.0
2008	50.0	50.0	51.0	50.0	51.0	52.0



FT Fuel Blending Affects on Density Based on JP-8 Statistics from 2003 in Region 2.

Maximum Percent of FT Fuel with Density of 0.751 g/mL in Blend to Maintain Minimum Density of 0.775 g/mL Based on PQIS Data from Region 3.

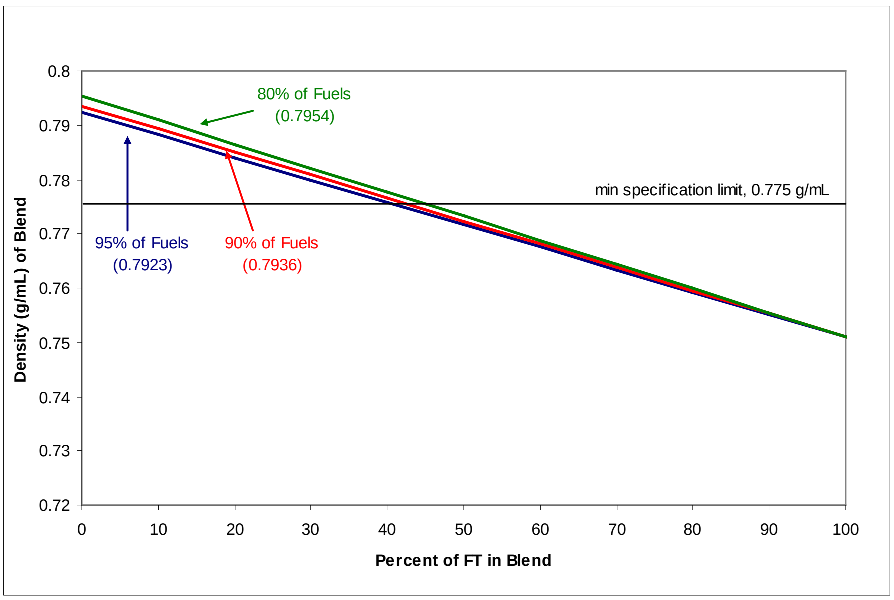
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Lognormal Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1999	41.5	44.2	44.2	40.0	41.5	44.2
2000	41.5	44.2	45.5	35.1	40.0	44.2
2001	36.8	40.0	41.5	35.1	40.0	42.9
2002	33.3	40.0	44.2	42.9	46.7	48.9
2003	36.8	40.0	44.2	41.5	45.5	47.8
2004	36.8	38.5	40.0	31.4	35.1	40.0
2005	36.8	38.5	41.5	36.8	40.0	44.2
2006	38.5	40.0	42.9	40.0	42.9	46.7
2007	36.8	38.5	41.5	40.0	42.9	45.5
2008	38.5	41.5	42.9	38.5	41.5	45.5



FT Fuel Blending Affects on Density Based on JP-8 Statistics from 2002 in Region 3.

Maximum Percent of FT Fuel with Density of 0.751 g/mL in Blend to Maintain Minimum Density of 0.775 g/mL Based on PQIS Data from Region 4.

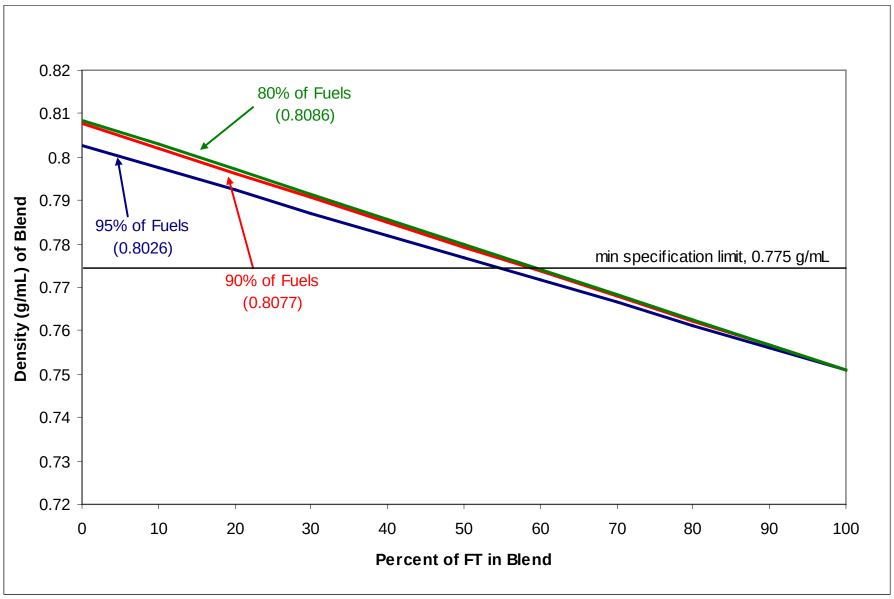
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Loglogistic Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1999	27.3	45.5	46.7	40.0	41.5	44.2
2000	41.5	44.2	45.5	41.5	42.9	45.5
2001	45.5	46.7	47.8	44.2	46.7	48.9
2002	44.2	45.5	46.7	42.9	45.5	47.8
2003	47.8	47.8	48.9	45.5	46.7	47.8
2004	47.8	48.9	50.0	46.7	47.8	48.9
2005	44.2	45.5	46.7	42.9	44.2	45.5
2006	44.2	45.5	45.5	41.5	42.9	45.5
2007	40.0	41.5	44.2	38.5	41.5	44.2
2008	46.7	46.7	47.8	45.5	46.7	47.8



FT Fuel Blending Affects on Density Based on JP-8 Statistics from 2000 in Region 4.

Maximum Percent of FT Fuel with Density of 0.751 g/mL in Blend to Maintain Minimum Density of 0.775 g/mL Based on PQIS Data from Region 5.

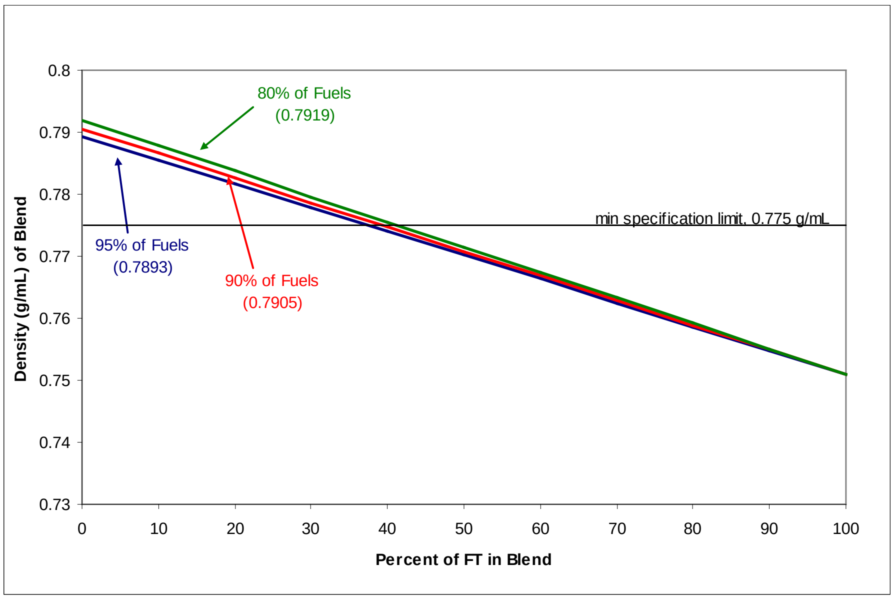
Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Lognormal Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1999	59.3	60.0	60.7	57.9	59.3	61.3
2000	58.6	58.6	59.3	54.7	56.4	57.9
2001	58.6	58.6	59.3	56.4	57.1	58.6
2002	57.9	59.3	59.3	57.1	57.9	59.3
2003	53.8	57.9	58.6	52.9	55.6	58.6
2004	55.6	57.1	57.9	53.8	56.4	59.3
2005	54.7	55.6	57.1	51.0	52.9	55.6
2006	57.1	57.9	58.6	55.6	57.1	58.6
2007	58.6	58.6	59.3	56.4	57.9	58.6
2008	58.6	59.3	60.7	58.6	59.3	60.0



FT Fuel Blending Affects on Density Based on JP-8 Statistics from 2003 in Region 5.

Maximum Percent of FT Fuel with Density of 0.751 g/mL in Blend to Maintain Minimum Density of 0.775 g/mL Based on PQIS Data from CONUS.

Year	Based on PQIS Data 95% Confidence	90% Confidence	80% Confidence	Based on Lognormal Distribution of PQIS Data 95% Confidence	90% Confidence	80% Confidence
1999	42.9	44.2	45.5	38.5	41.5	45.5
2000	42.9	45.5	46.7	38.5	41.5	45.5
2001	40.0	41.5	46.7	38.5	42.9	46.7
2002	38.5	42.9	50.0	41.5	45.5	48.9
2003	38.5	42.9	48.9	41.5	44.2	47.8
2004	36.8	40.0	41.5	35.1	38.5	42.9
2005	38.5	41.5	42.9	38.5	41.5	45.5
2006	38.5	41.5	46.7	40.0	44.2	46.7
2007	38.5	41.5	44.2	40.0	42.9	46.7
2008	40.0	41.5	44.2	40.0	42.9	46.7



FT Fuel Blending Affects on Density Based on JP-8 Statistics from 2004 in Regions 1-5.

8. Appendix B: Summary Version of Technical Report

Paper presented at the 11th International Conference on Stability, Handling and Use of Liquid Fuels in Prague, Czech Republic, October, 2009.

IASH 2007, the 11th International Conference on
Stability Handling and Use of Liquid Fuels
Prague, Czech Republic
October 18-22, 2009

VARIATION OF JP-8 PROPERTIES IN CONUS AND POTENTIAL IMPLICATIONS DURING BLENDING WITH SYNTHETIC PARAFFINIC KEROSENE (SPK)

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Keywords: Synthetic Paraffinic Kerosene (SPK), JP-8, Fuel Blend, PQIS, Statistical Analysis

ABSTRACT

There has been continued interest in the use of alternatively-derived (non-petroleum) fuels for aviation applications. Recently, the use of Synthetic Paraffinic Kerosene (SPK) produced via the Fischer-Tropsch (FT) process has received significant attention. Extensive laboratory and in-field research and development resulted in the recently modified JP-8 military fuel specification, MIL-DTL-83133F, which allows blending up to 50 volume % SPK with a certification JP-8 provided the fuel blend specification limits are satisfied. In order to facilitate domestic implementation, it is important to understand the impact of variations in the neat JP-8 fuel properties on the resulting fuel blends. In this effort, statistical analysis was performed to investigate the variation of selected JP-8 properties as a function of year (1997-2008) and region in the Continental United States (CONUS) in which the fuel was procured. The analysis indicated that statistically significant historical differences exist in certain fuel properties, including the total aromatic content and density, depending on the region in which the fuel was procured. Using the discrete data and trends determined for the neat JP-8 property values, the expected total aromatic content and density property values for fuel blends were calculated. A substantial probability exists that a 50 volume % blend of JP-8 with SPK will not meet the minimum fuel specification limits depending on the regional location where the fuel is procured. This will limit the maximum allowable percentage of SPK which can be used during implementation. Discussion of the statistical analyses performed, historical property trends, and implications during blending is provided.

INTRODUCTION

For each shipment of military fuel procured in the United States, the location, volume, and chemical and physical properties of the fuel are recorded by the Defense Energy and Support Center (DESC) in the Petroleum Quality Information System (PQIS) database. The DESC separates the Continental United States (CONUS) into five regions for which fuel procurements are tracked, as shown in Figure 1. World-wide fuel procurements (OCONUS) are also recorded as a function of region. DESC procures large volumes of JP-8 for the Department of Defense (DoD) in CONUS, with annual volumes typically between 1.5-2.0 billion gallons. Figure 2 shows the total volume of fuel procured in CONUS as a function of region from 1997-2008. As shown, there are significant differences in the total volume of fuel procured within each CONUS region while the respective percentages are relatively consistent. The majority of fuel is procured in Regions 2, 3 and 5 while Regions 1 and 4 account for a low percentage of the total.

Figure 1. DESC Regions 1-5 of the Continental United States (CONUS)

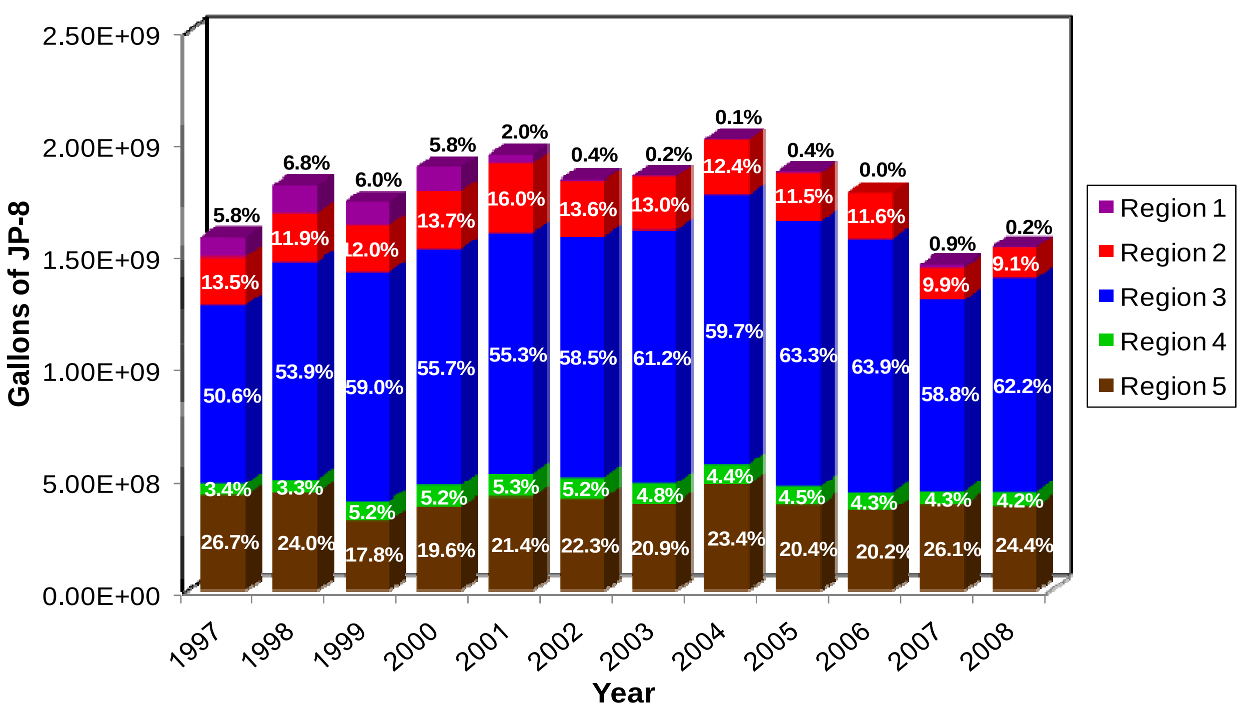

Figure 2. Total Volume of JP-8 Procured in Each Region of CONUS from 1997-2008

The availability of Synthetic Paraffinic Kerosene (SPK) produced via the Fischer-Tropsch (FT) process has provided a supplemental domestic fuel source. However, due to potential operational issues and limitations in available quantities, it will be necessary to blend the SPK fuel with JP-8 for near-term implementation. The JP-8 military fuel specification, MIL-DTL-83133F, was modified (11 April 2008) to allow blending of up to 50% SPK with a certification JP-8. More recently, the ASTM Petroleum Products and Lubricants Committee also approved the use of SPK fuel blends for commercial aircraft (D7566 approved 5 August 09). The resulting mixture must have a minimum aromatic content of 8.0% by volume, a minimum specific gravity of 0.775 g/mL, and satisfy all other specification requirements.

Recent efforts have focused on identifying the effect of blending an FT-derived SPK with JP-8 on the resulting chemical, physical, and Fit-for-Purpose (FFP) properties.[1-8] Improved understanding of the effect of blending on the resulting properties is needed to insure safe operability of aircraft and allow for implementation of FT-derived fuels. It has been found that the majority of fuel properties vary linearly with blend percentage provided that the SPK has a similar distillation range to a typical jet fuel with a sufficiently high *iso*-/normal alkane ratio. Understanding of the effect of blending is very useful since it allows for analysis of historical JP-8 property trends to determine anticipated fuel properties. In this effort, an analysis of the PQIS data for selected fuel properties was performed to investigate time-dependent statistical trends to determine if future blend property values can be predicted. Specifically, the 1999-2008 PQIS data (aromatic content from 1997-2008) were analyzed to determine if the properties of JP-8 fuel vary as a function of year and/or region in which the fuel was procured. Discrete data and trends were examined for the historical JP-8 property values and were used to predict resulting properties upon blending with SPK. This analysis also allows for estimation of the maximum percentage of synthetic fuel which could be blended while still satisfying the JP-8 fuel blend specifications. The following sections will summarize the statistical analyses performed for each fuel property of interest, the variance of these as a function of CONUS region and year, and discuss potential implications of blending on resulting fuel properties. This effort expands on a previous detailed analysis performed using the 2004 PQIS data.[4]

PQIS HISTORICAL DATA ANALYSIS

The Petroleum Quality Information System (PQIS) data from the years 1999-2008 was analyzed for selected fuel properties (1997-2008 for aromatic content) to identify if there are statistical differences in properties depending upon location of fuel procurement and year. The analysis was performed to determine if correlations exist which can allow for subsequent prediction of future property values. The data was analyzed individually as a function of region and combined for CONUS (as typically reported in the PQIS). In each region, the weight mean, standard deviation, and confidence intervals were calculated for each property as a function of year. It should be noted that the combined volume of fuel procured in Region 1 and 4 accounted for less than ten percent of the total volume of fuel procured annually in CONUS. Therefore, data analysis for Regions 2, 3 and 5 are believed to be more indicative of historical property trends and those expected in the future.

The next six sections contain detailed analyses of the PQIS data for the following JP-8 fuel properties: aromatic content, density, freeze point, viscosity, heat of combustion, and volumetric heating value (calculated). The PQIS data for each year and region were also fit using the probability distribution with the highest correlation. Consistency in mean values and trends in data can be readily determined by comparing the distribution curve fits of the random data and allow for prediction. Although the distribution curve fits are not presented herein, they can be found elsewhere.[9] The data for each property was analyzed independently as a function of year and region in which the fuel was procured. The data from the individual regions was then combined for CONUS to determine the statistical variance/trends in the respective properties. The specified range of values for each property and region represents the trend in the 90% confidence interval over the years analyzed.

Aromatic Content

The MIL-DTL-83133F fuel specification allows a total maximum aromatic content of 25.0% by volume with no minimum requirement. The latter is not required as aviation fuels produced from petroleum will always contain a significant aromatic concentration. The calculated weight mean aromatic content as a function of year from 1997-2008 for Regions 1-5 and CONUS are shown in Figure 3. From the analysis of the aromatic content of each region throughout the years 1997-2008, it is apparent that consistent trends exist within Regions 2, 3 and 5 and CONUS combined. However, the mean aromatic content of fuel procured in Regions 1 and 4 are not consistent. Although certain statistical trends exist for the mean aromatic content, it should be noted that there are distinct differences in the distributions for the discrete fuel procurements. The aromatic content for the combined individual procurements from 1997-2008 as a function or Region are shown in Figure 4; it can readily be observed that there are differences in the distribution shapes and confidence intervals from the mean values.

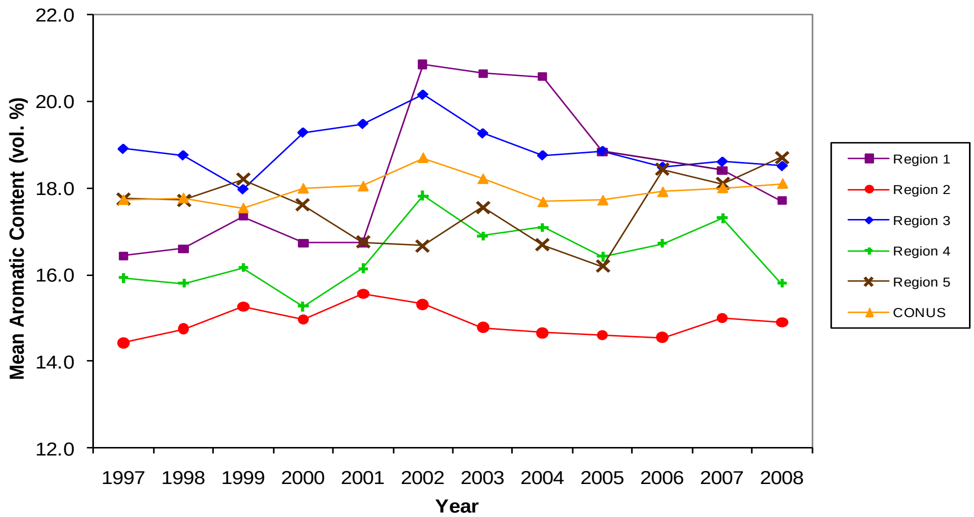

Figure 3. Weight Mean Aromatic Content from Years 1997-2008 as a Function of Region and CONUS

Based on the historical aromatic content data from Regions 1 and 4, there are not consistent trends in the mean aromatic content of fuel procured throughout all years. In Region 1, there is a distinct shift for fuel procured in the years 1997-2001 (16.7 vol. %) to that in 2002-2004 (20.0 vol. %), with a slight decline in 2005 and 2007-2008 (18.0 vol. %). In the years 2002-2005 and 2007, there was only a low total volume of fuel procured with an aromatic content of less than 17.0 vol. %, resulting in higher weight means than in the previous years. The relative consistency in the mean aromatic content over the last six years allows for the prediction of the average aromatic content of fuel procured in Region 1 of 19.0 vol. % within a 90% confidence range of 17.0 to 23.0 vol. %.

In Region 4, there is a slight variation in the weight mean throughout all years ranging from 15.3 to 17.8 vol. % aromatic content, being slightly lower in 1997-2001 and 2008 (approximately 16.0%) than in 2002-2007 (approximately 17.0%). The low number of annual fuel procurements in Region 4 have considerable variation in aromatic content ranging from 11.0 to 23.0 vol. %. Due to the wide range in aromatic content as well as the relatively low volume of fuel procured

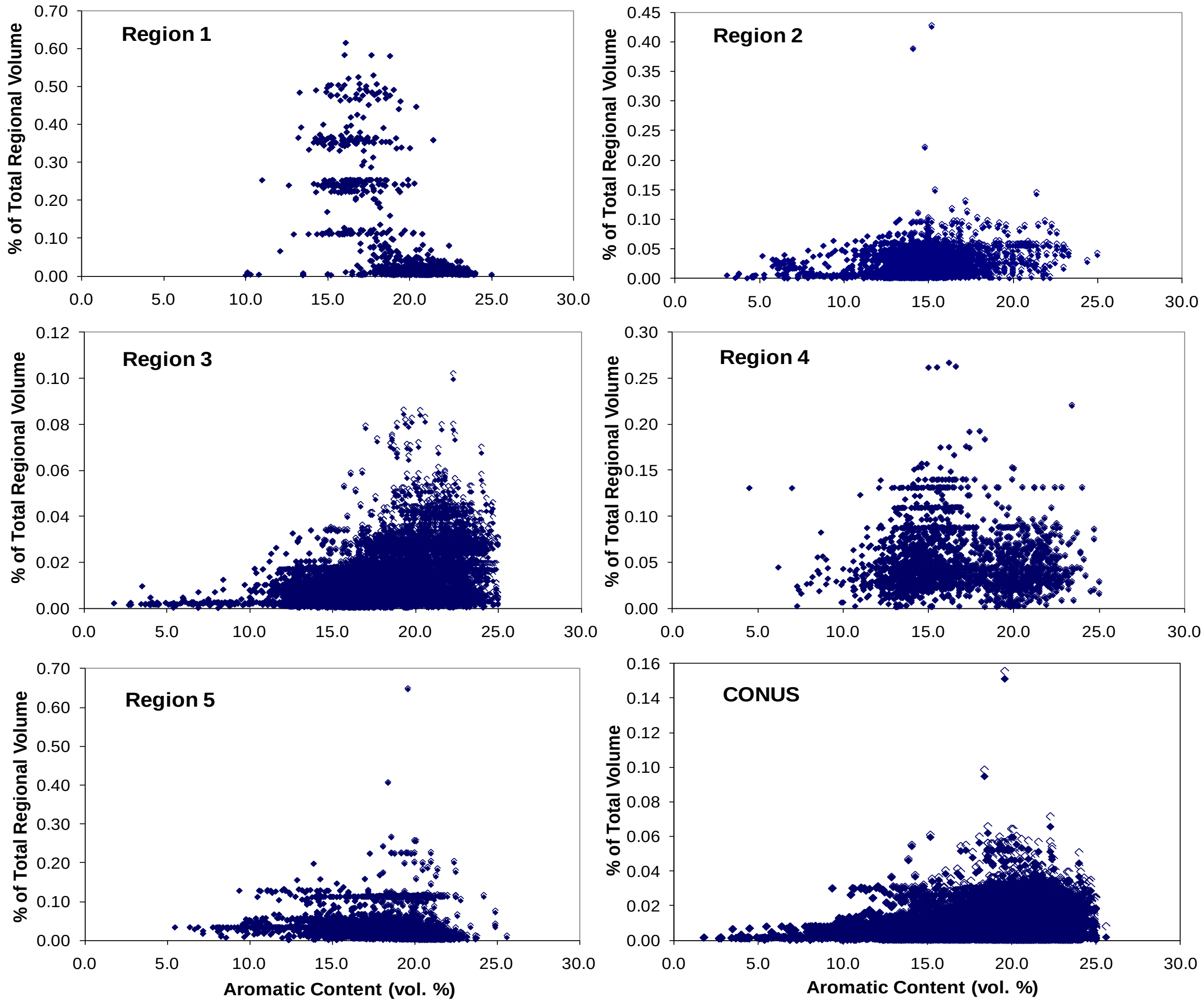

Figure 4. Combined PQIS Aromatic Content Values from 1997-2008 as a Function of Region

in Region 4 throughout the years 1997-2008 (see Figure 2), the mean aromatic content cannot be predicted with a high degree of certainty. Since the fuel procured in Regions 1 and 4 accounts for less than ten percent of the total fuel procured annually within CONUS, Regions 1 and 4 are prone to increased variability and are not indicative of cumulative trends.

In Regions 2, 3 and 5, there are consistent trends in the historical mean aromatic content data that can be useful in predicting aromatic content of fuels from these regions. In Region 2, there is a clear consistency in the weight mean of approximately 15.0 vol. % aromatic content throughout all twelve years. This average content is appreciably lower than for other regions and the CONUS average, with the differences being statistically significant. The procurement of fuel with very low and/or high aromatic content was inconsistent throughout all years. The fuel procured in Region 2 had a wide range of aromatic content, ranging from 12.0 to 20.0 vol. %. Due to the procurement of large volumes of fuel with lower aromatic content and only a few high volume procurements with high aromatic content, the aromatic content data for Region 2 is right-skewed. The aromatic content of fuel procured in Region 3 has been consistent within a range of 14.0 to 23.0 vol. % with a mean value of approximately 19.0 vol. % due to a consistently large volume of fuel procured with high aromatic content. The aromatic content data for Region 3 is left-skewed due to a few low volume fuel procurements with low aromatic content and a large volume of fuel procured with high aromatic content (see Figure 4). With the exception of a few years in Region 5, the weight mean of the aromatic content is consistently about 18.0 vol. %. Some of the years have a slightly lower mean aromatic content due to high volume procurements with low aromatic content. The aromatic content of fuel procured in Region 5 has been consistent within a range of 13.0 to 21.0 vol. %. Due to a small number of large procurements with low aromatic content, the data for Region 5 is also left-skewed.

Throughout the years 1997-2008, the aromatic content of fuel procured in CONUS has been consistent within a range of 13.0 to 22.0 vol. % with a mean value of approximately 18.0 vol. %. The data for CONUS is left-skewed due to a number of low volume fuel procurements with low aromatic content and larger volume procurements with high aromatic content. A summary of the trends in aromatic content mean statistics and the 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 1. The confidence intervals were calculated using the discrete data rather than incorporating a functional curve fit; thus, they represent the range of discrete aromatic contents for which the corresponding percentage of fuel would reside. With the exception of Region 4, the aromatic content of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 1.

Table 1. Overall Aromatic Content Statistics for Each Region and CONUS based on the PQIS Data from 1997-2008

Region	Mean	60% CI	80% CI
1	19.0*	18.0 - 21.0	**
2	15.0	13.4 - 16.8	12.5 – 17.0
3	19.0	16.0 - 22.0	14.5 – 22.5
4	**	14.0 – 20.0*	13.5 – 21.0*
5	18.0	15.0 - 20.0	**
CONUS	18.0	15.0 - 20.5	14.0 – 22.0

* Consistent over last few years, allowing for future predictions
** Not consistent for consecutive years, cannot be predicted

Analysis of the aromatic content as a function of year and region for JP-8 procured during 1997-2008 has shown that consistent mean values (Figure 3) and variation exist within individual regions and for CONUS. However, as shown in Figure 4 and Table 1, there are statistical differences between the fuels procured in different regions. This is not evident when only reviewing the historical trends for CONUS, and it is apparent that significant over-/underestimations of expected aromatic content could occur if the expected properties are based solely on CONUS. If all regions of CONUS were considered concurrently, the aromatic content of fuel procured in Regions 1, 2 and 4 will be consistently overestimated resulting in inaccurate prediction of aromatic content. The cause of the significant variations in the average aromatic content and distribution are not readily known, but could be related to the properties of the petroleum/crude oil and/or refining conditions employed in these respective regions. With such statistical differences between the aromatic content of the fuel between most of the regions, the regions may need to be considered independently when analyzing property distributions and variance over time. *The prediction of the aromatic content based solely on the analysis of CONUS combined would produce a statistically inaccurate estimation of aromatic content.*

Density

The MIL-DTL-83133F fuel specification requires JP-8 to have a density within the range of 0.775 – 0.840 g/mL. The calculated weight mean density as a function of year from 1999-2008 for Regions 1-5 and CONUS is shown in Figure 5. From the analysis of the density of each region, it is apparent that consistent trends independently exist within Regions 2-5 and CONUS combined. The density of fuel in Region 1 has shown a wide range of variability throughout 1999-2008, which is intensified by the low total volume of fuel procured in this region. The fuel procured within Region 5 had a consistently higher density than the fuel procured in the other regions. Although the mean density was statistically similar within each region, there are distinct differences in the distributions for the discrete fuel procurements. The density values for the combined individual procurements from 1999-2008 as a function of region are shown in Figure 6; there are substantial differences in the distribution shapes and confidence intervals from the mean values.

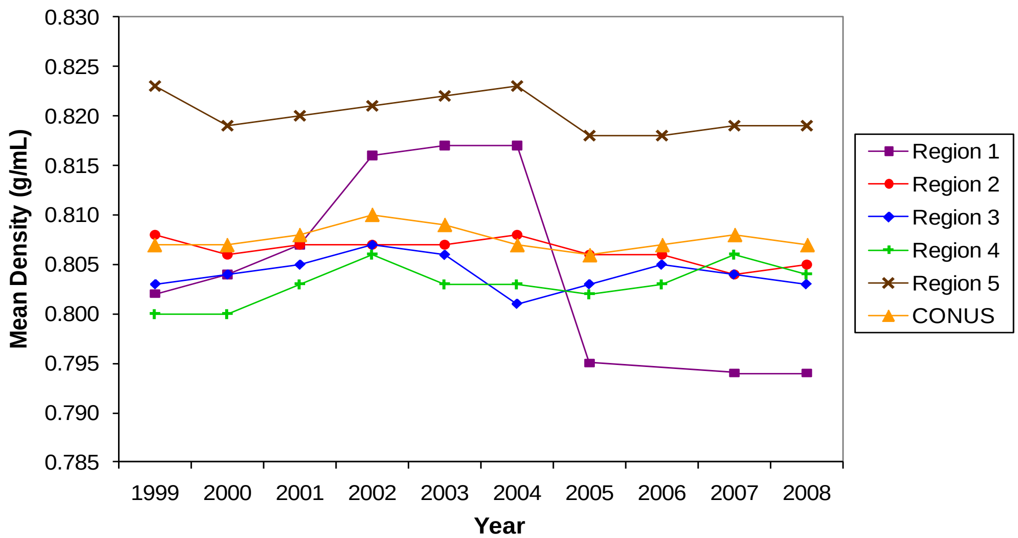

Figure 5. Weight Mean Density from Years 1999-2008 as a Function of Region and CONUS

Based on the historical density data, there is no consistency in the density of fuel procured throughout all years in Region 1. There is a distinct increase in the mean density of fuel procured in the years 1999-2001, 2005, and 2007-2008 (0.800 g/mL) to the fuel procured in 2002-2004 (0.817 g/mL). The mean density of fuel procured in 2005 and 2007-2008 (0.794 g/mL) is slightly lower than in 1999-2001 since there was a lower volume of high density fuel procured. In the years 2002-2004, a larger volume of fuel was procured with a high density than in the previous years, resulting in the higher weight means. The range in the density as well as the volume of each fuel procurement in Region 1 is not consistent for more than three consecutive years from 1999-2008. Therefore, the density of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 is not indicative of historical trends.

In Regions 2-5, there are trends in the historical data that can be useful in predicting density of fuels from these regions. In Region 2, there is a clear consistency in the weight mean density of approximately 0.807 g/mL (range of 0.799 to 0.818) throughout all ten years, which is consistent with trends in the aromatic content from this region. Due to the procurement of a large volume

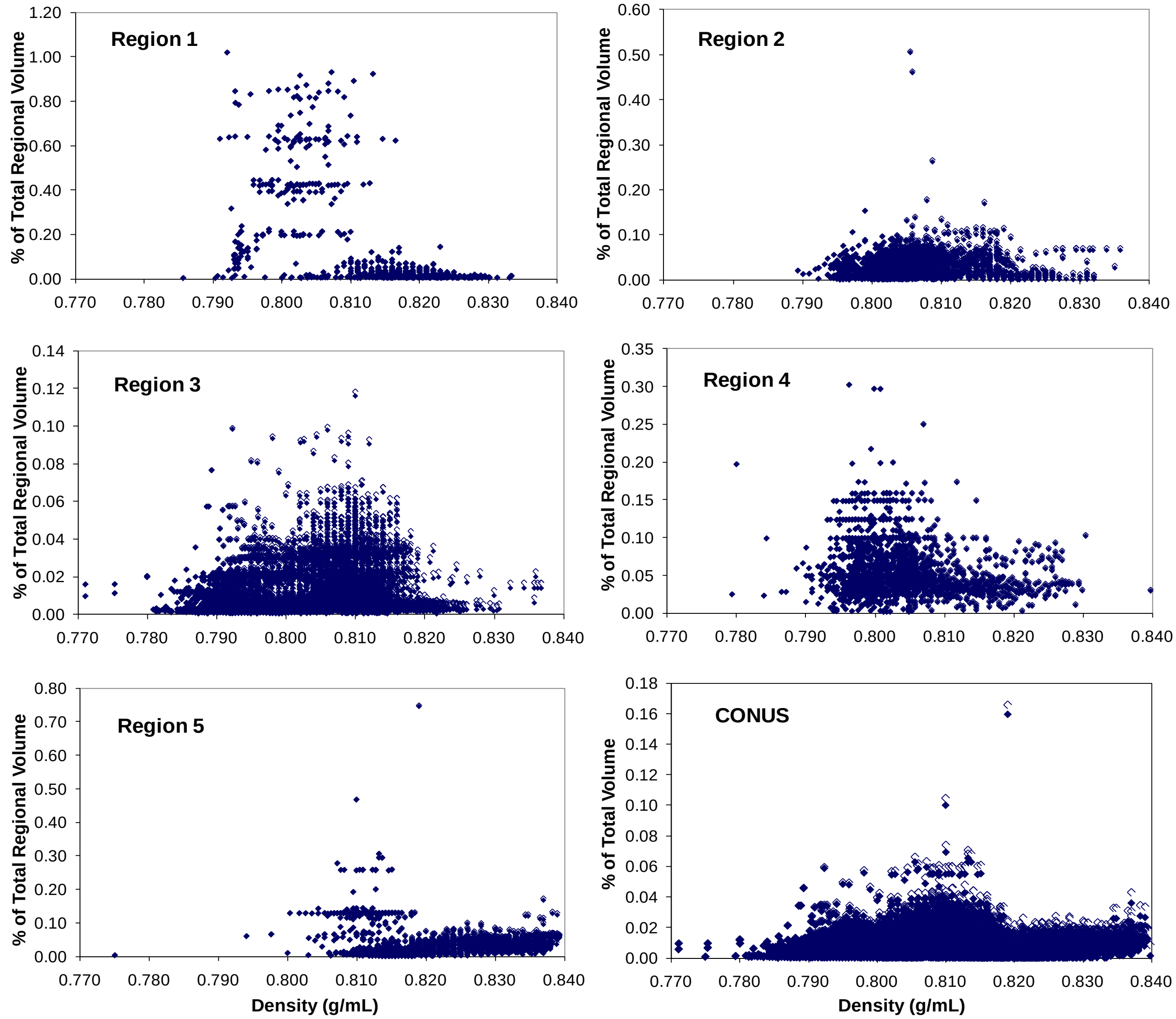

Figure 6. Combined PQIS Density Values from 1999-2008 as a Function of Region

of fuel with low density and only a few high volume procurements of fuel with high density, the density data for Region 2 is right-skewed. The density of fuel procured in Region 3 has been consistent within a range of 0.792 to 0.815 g/mL with a mean value of approximately 0.805 g/mL. With the exception of 2002 and 2007, the density of fuel procured in Region 4 has a weight mean density consistently about 0.803 g/mL. In these years, there were a few high volume procurements of fuel with high density resulting in a higher weight mean of 0.806 g/mL (range of 0.792 to 0.817 g/mL). Due to low volume fuel procurements with high density, the density data for Regions 3 and 4 are right-skewed. The density of fuel procured in Region 5 has been consistent within a range of 0.805 to 0.838 g/mL with a mean value of approximately 0.820 g/mL. Due to a small number of large volume procurements with low density and low volume procurements with high density, the data for Region 5 is also right-skewed.

The density of fuel procured in CONUS has been consistent within a range of 0.792 to 0.825 g/mL with a mean value of approximately 0.807 g/mL. The data for CONUS is right-skewed due to a number of low volume fuel procurements with high density. A summary of trends in density mean statistics and the 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 2. With the exception of Region 1, the density of fuel procured in each region has been consistent and can be accurately predicted within the ranges and with the mean values shown. The combined average CONUS density and confidence interval is higher than regions 1-4 due to the contribution of the substantially higher Region 5 values.

Table 2. Overall Density Statistics for Each Region and CONUS based on PQIS Data for 1999-2008

Region	Mean	60% CI	80% CI
1	**	**	**
2	0.807	0.804 - 0.810	0.801 – 0.812
3	0.805	0.797 - 0.810	0.793 – 0.813
4	0.803	0.798 - 0.812	0.797 – 0.817
5	0.820	0.811 - 0.832	0.810 – 0.835
CONUS	0.807	0.799 - 0.813	0.795 – 0.820
** Not consistent for consecutive years, cannot be predicted.			

Analysis of the density as a function of year and region for JP-8 procured from 1999-2008 has shown relatively consistent mean values (Figure 5) and variation exist within individual regions and CONUS. However, as shown in Figure 6 and Table 2, there are statistical differences between fuels procured in different regions. With such statistical differences, the regions may need to be considered independently when analyzing property distributions and changes over time. If all regions of CONUS were considered as one, the density of a portion of the fuel procured in Regions 1, 3 and 4 would be overestimated and Region 5 would be substantially underestimated resulting in inaccurate predictions. *The prediction of the density of fuel based solely on the analysis of CONUS combined would render a statistically inaccurate estimation of the density. Therefore, the predictability of the density of fuel is dependent on the region of CONUS in which the fuel is procured.*

Freeze Point

The MIL-DTL-83133F fuel specification currently requires JP-8 to have a maximum (<) freeze point of -47.0°C. The calculated weight mean freeze point as a function of year from 1999-2008 for Regions 1-5 and CONUS is shown in Figure 7. From the analysis of the freeze point of each region it is apparent that there exists consistent trends within Regions 2-5 and CONUS combined. The freeze point of fuel procured in Region 1 has shown a wide range of variability throughout 1999-2007. The fuel procured within Region 5 had a consistently lower freeze point than the fuel procured in the other regions. The inconsistency in mean freeze point within Region 1 and the lower freeze point of fuel procured in Region 5 can been seen in Figure 7.

Based on the historical freeze point data, there is no consistency in the freeze point of fuel procured throughout all years for Region 1. There is a distinct increase in the freeze point of fuel procured in the years 1999-2001 and 2003 (-58.0ºC) to the fuel procured in 2004, 2005, and 2007 (-53.4, -49.4, and -49.7ºC). However there was a distinct decrease in the freeze point in 2002 to -61.0ºC due to the procurement of a large volume of fuel with low freeze point. The range in the freeze point as well as the volume of each fuel purchase in Region 1 was not consistent for more than three consecutive years from 1999-2007. Therefore, the freeze point of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in

Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of historical trends.

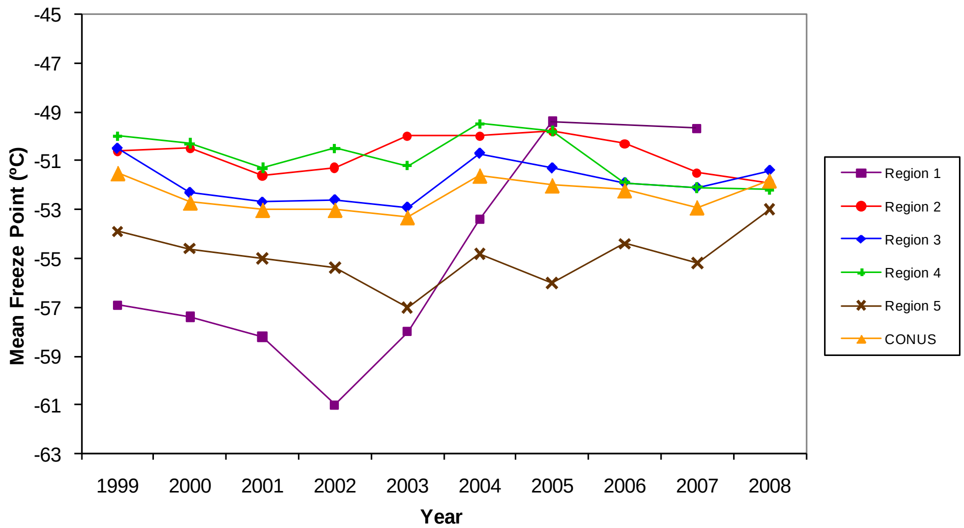

Figure 7. Weight Mean Freeze Point from Years 1997-2008 as a Function of Region and CONUS

In Regions 2-5, there are trends in the historical freeze point data that can be useful in predicting freeze point of fuels from these regions. The freeze point of fuel procured in Region 2 has been consistent within a range of -60.0 to -47.0ºC with a mean value of -50.0ºC. In Region 3, the freeze point of the fuel procured has been consistent within a range of -62.0 to -47.0ºC with a mean value about -52.0ºC. The freeze point of fuel procured in Region 4 has been consistent within a range of -60.0 to -47.0ºC with a mean value of -51.0ºC. Due to the procurement of more fuel with freeze point near the maximum specification of -47.0ºC and only a few high volume procurements of fuel with low freeze point, the freeze point data for Regions 2, 3, and 4 is left-skewed. The freeze point of fuel procured in Region 5 has been consistent within a range of -70.0 to -47.0ºC with a mean value of approximately -55.0ºC. The freeze point data for Region 5 is also left-skewed because of a low volume of fuel procurements with a low freeze point and high volume of fuel procurements with a higher freeze point. The distribution shapes for freeze point are expected based on the specification only requiring a maximum freeze point; Jet A-1 will be processed to have the majority of fuel volume satisfy the requirement while further improvement is unnecessary.

The freeze point characteristics of fuel procured in CONUS has been within a range of -65.0 to -47.0ºC with a mean value of approximately -52.0ºC. The data for CONUS is left-skewed because of a number of low volume fuel procurements with a low freeze point. Although the combined analysis of CONUS was consistent, the difference between individual regions is too substantial to disregard and analyze all regions together. A summary of trends in freeze point mean statistics and the 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 3. With the exception of Region 1, the freeze point of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 3.

Table 3. Overall Freeze Point Statistics for Each Region and CONUS based On the PQIS Data for 1999-2008

Region	Mean	60% CI	80% CI
1	**	**	**
2	-50.0	-52.0 to -48.8	-53.5 to -48.0*
3	-52.0	-55.5 to -49.0	-57.0 to -48.0
4	-51.0	-53.0 to -48.5	**
5	-55.0	-62.0 to -50.0	-64.0 to -49.0
CONUS	-52.0	-56.0 to -48.7	-59.0 to -48.1*

*Consistent over last five years, allowing for future predictions.
** Not consistent for consecutive years, cannot be predicted.

Overall, based on the analysis of the freeze point of fuel procured in individual Regions 1-5 and CONUS combined, there are statistical differences in the lower range of the freeze point for each region. The prediction of the freeze point of fuel based on the analysis of CONUS combined would produce a statistically inaccurate estimation of the freeze point. *Therefore, the predictability of the freeze point of fuel is dependent on the region of CONUS in which the fuel is procured. However, for this specific property, variances in the value and distribution may not be of significant concern.* Previous studies have shown that if the SPK has a similar volatility range and high *iso*-/normal paraffin ratio, the freeze point will vary linearly with blend ratio. If the SPK has a freeze point which satisfies the -47 ºC specification, it is highly probably that the blend will satisfy requirements.

Kinematic Viscosity

The MIL-DTL-83133F fuel specification currently requires JP-8 to have a maximum kinematic viscosity (at -20°C) of 8.0 mm^2/s. The calculated weight mean viscosity as a function of year from 1999-2008 for Regions 1-5 and CONUS is shown in Figure 8. From the analysis of the kinematic viscosity of each region it is apparent that there exists consistent trends within Regions 2-5 and CONUS combined. The viscosity of fuel procured in Region 1 has shown a wide range of variability throughout 1999-2007. Figure 8 shows the mean viscosity as a function of years from 1999-2008 for Regions 1-5 of CONUS.

Based on the historical viscosity data, there is no consistency in the viscosity of fuel procured throughout all years for Region 1. There is a distinct increase in the viscosity of fuel procured in the years 2000, 2001, 2005, and 2007 (4.03 mm^2/s) to the fuel procured in 2002-2004 (4.37 to 4.81 mm^2/s). However, the fuel procured in 1999 had a lower mean value (3.60 mm^2/s) than all other years due to the procurement of a large volume of fuel with low viscosity. The range in the viscosity as well as the volume of each fuel procurement in Region 1 was not consistent for more than three consecutive years from 1999-2007. Therefore, the viscosity of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of historical trends.

In Regions 2-5, there is a trend in the historical kinematic viscosity data that can be useful in predicting property trends from these regions. The viscosity of fuel procured in Region 2 has been consistent within a range of 3.80 to 6.00 mm^2/s with a mean value of 4.85 mm^2/s. The viscosity of fuel procured in Region 4 has been consistent within a range of 2.70 to 6.00 mm^2/s

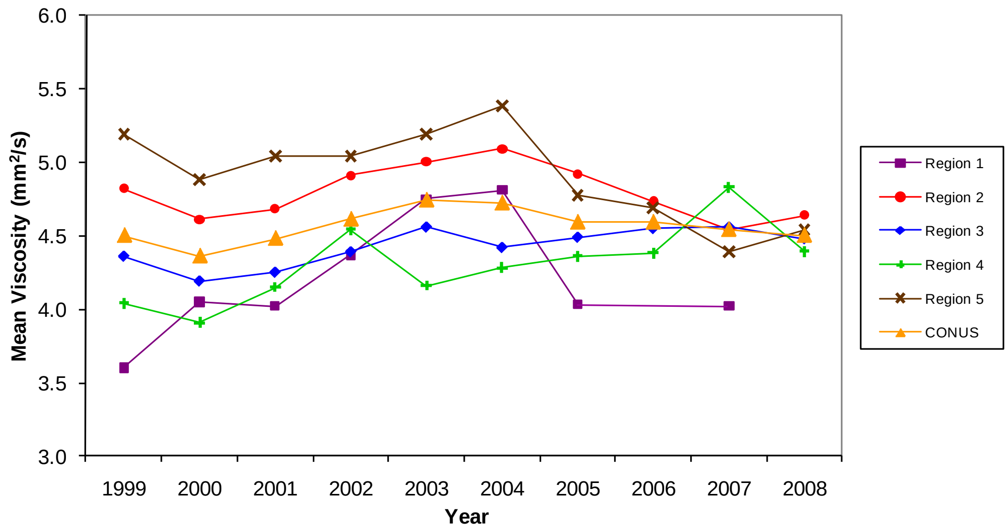

Figure 8. Weight Mean Viscosity from Years 1997-2008 as a Function of Region and CONUS

with a mean value of 4.26 mm²/s. Due to a few high volume fuel procurements with a high viscosity, the viscosity data for Regions 2 and 4 is right-skewed. The viscosity of fuel procured in Region 3 has been consistent within a range of 2.50 to 6.20 mm²/s with a mean value about 4.40 mm²/s. The data for Region 3 is normally distributed because the viscosity of the fuel procured is symmetrically distributed about the mean viscosity. The viscosity of fuel procured in Region 5 has been consistent within a range of 3.70 to 6.70 mm²/s with slightly inconsistent mean values. The mean viscosity in the years 2005-2008 has been consistently lower, about 4.60 mm^2/s, than in previous years. This recent consistency allows for prediction of the viscosity of fuel procured in Region 5. Due to a number of high volumes of fuel procurements with a lower viscosity and a few fuel procurements with a high viscosity, the viscosity data is right-skewed for Region 5.

The viscosity of fuel procured in CONUS has been consistent within a range of 2.70 to 6.40 mm²/s with a mean value of approximately 4.59 mm²/s. The data for CONUS is right-skewed because of a few high volume fuel procurements with a high viscosity. Although the combined analysis of CONUS was consistent, the difference between regions is too substantial to disregard and analyze all regions together. A summary of trends in viscosity mean statistics and the 60% confidence intervals for each region and CONUS combined is shown in Table 4. The 80% confidence intervals are not consistent throughout the years in each region and thus cannot be used for future predictions. With the exception of Region 1, the viscosity of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 4.

Overall, based on the analysis of the viscosity of fuel procured in individual Regions 1-5 and CONUS combined, there are statistical differences in the mean value (approximately ±0.5) and range of viscosity. *The prediction of the viscosity of fuel based on the analysis of CONUS combined would produce a statistically inaccurate estimation of the viscosity.* Therefore, the predictability of the viscosity of fuel is dependent on the region of CONUS in which the fuel is procured. However, the weight means and confidence intervals are well within the specification range of 8.00 mm²/s.

Table 4. Overall Viscosity Statistics for Each Region and CONUS based on the PQIS Data for 1999-2008

Region	Mean	60% CI
1	**	**
2	4.85	4.45 – 5.10
3	4.40	3.80 – 5.00
4	4.26	3.85 – 4.60
5	4.60*	4.20 – 5.00
CONUS	4.59	3.95 – 5.10

* Consistent over last four years, allowing for future predictions

** Not consistent for consecutive years, cannot be predicted

Heat of Combustion (by Mass)

The specification minimum requirement for the measured heat of combustion on a mass basis is 42.80 MJ/kg. The calculated weight mean heat of combustion as a function of year from 1999-2008 for Regions 1-5 and CONUS is shown in Figure 9. Analysis of the heat of combustion of each region showed consistent trends within Regions 1-5 and CONUS combined throughout all years. The mean heat of combustion is consistently lower for Region 5. The fuel procured in Region 2 has a consistently high mean heat of combustion with little variation throughout all years, which correlates with the lower aromatic content than in other regions. Overall, the mean heat of combustion of each region is within a range of 43.04 to 43.32 MJ/kg.

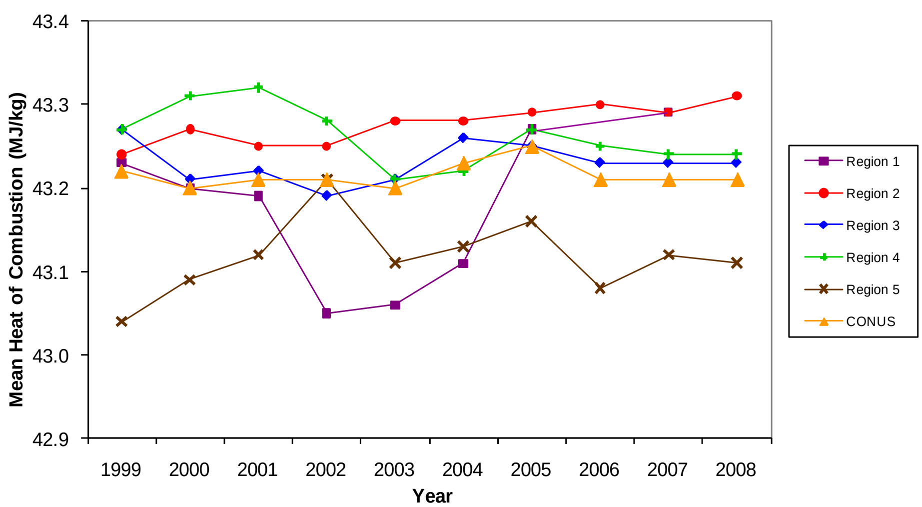

Figure 9. Weight Mean Heat of Combustion from Years 1997-2008 as a Function of Region and CONUS

In Regions 1-5, there is a trend in the historical heat of combustion data that can be useful in predicting heat of combustion of fuels from these regions. The heat of combustion of fuel procured in Region 1 has been consistent within a range of 43.00 to 43.30 MJ/kg with a mean value of approximately 43.25 MJ/kg for most years. The weight mean is lower in 2002-2004 (about 43.07 MJ/kg) because there were a few large volume fuel procurements with a lower heat of combustion than in other years. The heat of combustion of fuel procured in Region 2 has been consistent within a range of 43.00 to 43.45 MJ/kg with a mean value of 43.30 MJ/kg. Due to a few fuel procurements with a low heat of combustion in each year, the heat of combustion data for Regions 1 and 2 is left-skewed. The heat of combustion of fuel procured in Region 3 has been consistent within a range of 43.00 to 43.50 MJ/kg with a mean value about 43.20 MJ/kg. The heat of combustion of fuel procured in Region 4 has been consistent within a range of 43.00 to 43.80 MJ/kg with a mean value of about 43.25 MJ/kg. The heat of combustion of fuel procured in Region 5 has been consistent within a range of 42.90 to 44.00 MJ/kg with a mean value of about 43.10 MJ/kg. Due to a few high volume fuel procurements with a high heat of combustion, the heat of combustion data for Regions 3, 4, and 5 is right-skewed.

The heat of combustion of fuel procured in CONUS has been consistent within a range of 42.90 to 44.00 MJ/kg with a mean value approximately 43.20 MJ/kg. The data for CONUS is right-skewed because of a number of fuel procurements with a high heat of combustion. A summary of trends in heat of combustion mean statistics and the 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 5.

Table 5. Overall Heat of Combustion Statistics for Each Region and CONUS based on the PQIS Data for 1999-2008

Region	Mean	60% CI	80% CI
1	43.25	43.10 - 43.30	43.05 – 43.30
2	43.30	43.20 - 43.35	43.15 – 43.40
3	43.20	43.10 - 43.30	43.10 – 43.40
4	43.25	43.15 - 43.30	43.10 – 43.40*
5	43.10	43.00 - 43.20	43.00 – 43.25*
CONUS	43.20	43.10 – 43.30	43.00 – 43.40
*Consistent over last six years, allowing for future prediction.			

Overall, based on the analysis of the heat of combustion of fuel procured in individual Regions 1-5 and CONUS combined, there are minimal differences in the range of the heat of combustion over the years 1999-2006. *The prediction of the heat of combustion of fuel based on the analysis of CONUS combined (weight mean of approximately 43.20 MJ/kg) would produce a statistically accurate estimation of the heat of combustion for each region. Therefore, it appears acceptable that the predictability of the heat of combustion by mass of fuel is relatively independent of the CONUS region in which the fuel is procured.* It should also be noted that SPKs will typically have a higher heat of combustion value by mass due to a higher inherent hydrogen content; therefore, blending will increase this value relative to the neat JP-8 fuel.

Volumetric Heating Value

The following section analyzes the calculated volumetric heating value from regions 1-5 of CONUS for the years 1999-2008. Volumetric heating value is not a directly measured specification requirement, but may be important for fuel volume-limited applications and combustion performance due to the inherently lower density for SPK fuels. The volumetric heating value (VHV) was calculated from the PQIS heat of combustion (by mass) and density data:

$$VHV(MJ/Liter) = \left(HC\frac{MJ}{kg}\right)\left(Density\frac{g}{mL}\right)\left(\frac{kg}{1000\,g}\right)\left(\frac{1000\,mL}{Liter}\right)$$

The calculated mean volumetric heating value as a function of year from 1999-2008 for Regions 1-5 of CONUS is shown in Figure 10. From the analysis of the volumetric heating value of each region it is apparent that there exist consistent trends within Regions 2-5 and CONUS combined. The volumetric heating value of fuel procured in Region 1 is inconsistent throughout all years. The fuel procured in Region 5 had a consistently higher volumetric heating value than in all other regions. The inconsistencies within Region 1 and the high volumetric heating values in Region 5 can be seen in Figure 10.

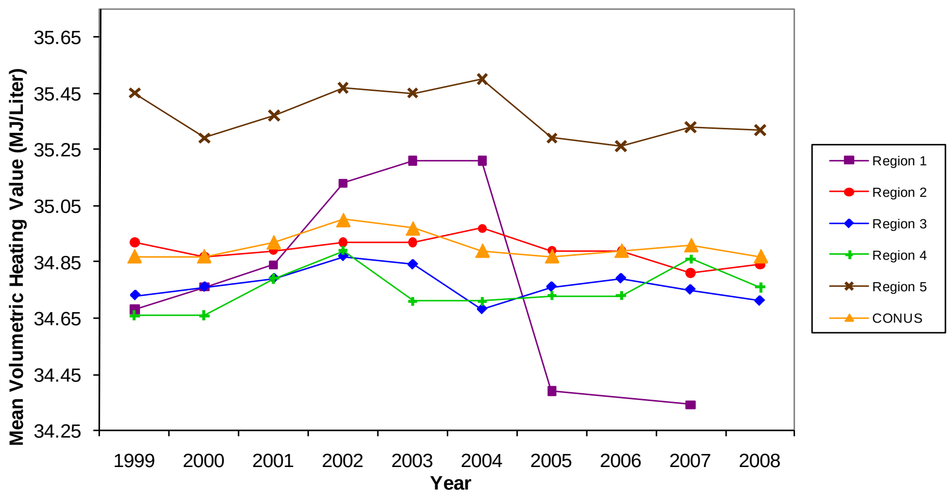

Figure 10. Weight Mean Volumetric Heating Value from Years 1999-2008 as a Function of Region and CONUS

Based on the historical volumetric heating value data from Region 1, there is no consistency in the volumetric heating value of fuel procured throughout all years. There is a distinct increase in the volumetric heating value of fuel procured in the years 1999-2001 (34.76 MJ/Liter) to the fuel procured in 2002-2004 (35.21 MJ/Liter). The mean volumetric heating value then decreases in 2005 and 2007 to approximately 34.35 MJ/Liter. The range in the volumetric heating value as well as the volume of each fuel procurement in Region 1 is not consistent for more than three consecutive years from 1999-2007. Therefore, the volumetric heating value of fuel procured in Region 1 cannot be predicted with a high degree of certainty. Since the fuel procured in Region 1 accounts for less than five percent of the total fuel procured annually within CONUS, Region 1 may not be indicative of historical trends.

In Regions 2-5, there is a trend in the historical volumetric heating value data that can be useful in independently predicting this property. The volumetric heating value of fuel procured in Region 2 has been consistent within a range of 34.55 to 35.39 with a mean value of 34.90 MJ/Liter. The volumetric heating value of fuel procured in Region 4 has been consistent within a range of 34.29 to 35.39 with a mean value about 34.71 MJ/Liter. Due to a small number of large volume fuel procurements with a high volumetric heating value, the data for Regions 2 and 4 is right-skewed. The volumetric heating value of fuel procured in Region 3 has been consistent within a range of 34.21 to 35.39 with a mean value about 34.80 MJ/Liter. The volumetric heating value of fuel procured in Region 5 has been consistent within a range of 34.84 to 35.95 with a mean value of about 35.39 MJ/Liter. Due to a number of fuel procurements with a high volumetric heating value, the data for Regions 3 and 5 is also right-skewed.

The volumetric heating value of fuel procured in CONUS has been consistent within a range of 34.29 to 35.95 with a mean value about 34.92 MJ/Liter. The data for CONUS is right-skewed because of a few high volume fuel procurements with a high volumetric heating value. Although the combined analysis of CONUS was consistent, the difference in the volumetric heating value in Region 5 and Regions 1-4 is too significant to ignore and analyze all regions together. In general, the trends and differences in the VHV are consistent to those observed in density (see Figure 5); this is reasonable since these properties are related linearly. It is noteworthy that although the heat of combustion by mass for Region 5 showed the lowest mean values, the calculated VHV is higher due to the significantly higher mean density values. A summary of trends in volumetric heating value mean statistics and the 60 and 80% confidence intervals for each region and CONUS combined is shown in Table 6. With the exception of Region 1, the volumetric heating value of fuel procured in each region can be accurately predicted within the ranges and with the mean values listed in Table 6.

Table 6. Overall Volumetric Heating Value Statistics for Each Region and CONUS based on the PQIS Data for 1999-2008

Region	Mean	60 % CI	80% CI
1	**	**	**
2	34.90	34.80 - 35.02	34.75 – 35.10
3	34.80	34.50 - 35.00	34.40 – 35.10
4	34.71	34.55 – 34.95	34.45 – 35.30*
5	35.39	35.05 - 35.75	34.97 – 35.90
CONUS	34.92	34.60 - 35.10	34.45 – 35.40

*Consistent over last four years, allowing for future prediction.
** Not consistent for consecutive years, cannot be predicted.

Overall, based on the analysis of the volumetric heating value of fuel procured in individual Regions 1-5 and CONUS combined, there is a statistical difference in the range of the volumetric heating value of fuel procured in Region 5 from the fuel procured in Regions 1-4. *The prediction of the volumetric heating value of fuel based on the analysis of CONUS combined would not necessarily produce a statistically accurate estimation of the volumetric heating value of Region 5.* Therefore, the predictability of the volumetric heating value of fuel is dependent on the region of CONUS in which the fuel is procured.

Property Correlations

Analysis was performed to determine if correlations exist between any of the JP-8 fuel properties discussed in the preceding sections. The existence of a correlation between any two JP-8 properties could assist with prediction of an expected property value with knowledge of the other. Figure 11 shows examples of strong and weak property correlations based on the 2008 PQIS Data. As shown, heat of combustion and density show a strong correlation (possibly due to hydrogen/carbon ratio); whereas density and aromatics have a weak correlation. These correlations have been consistent throughout the years considered in this analysis.

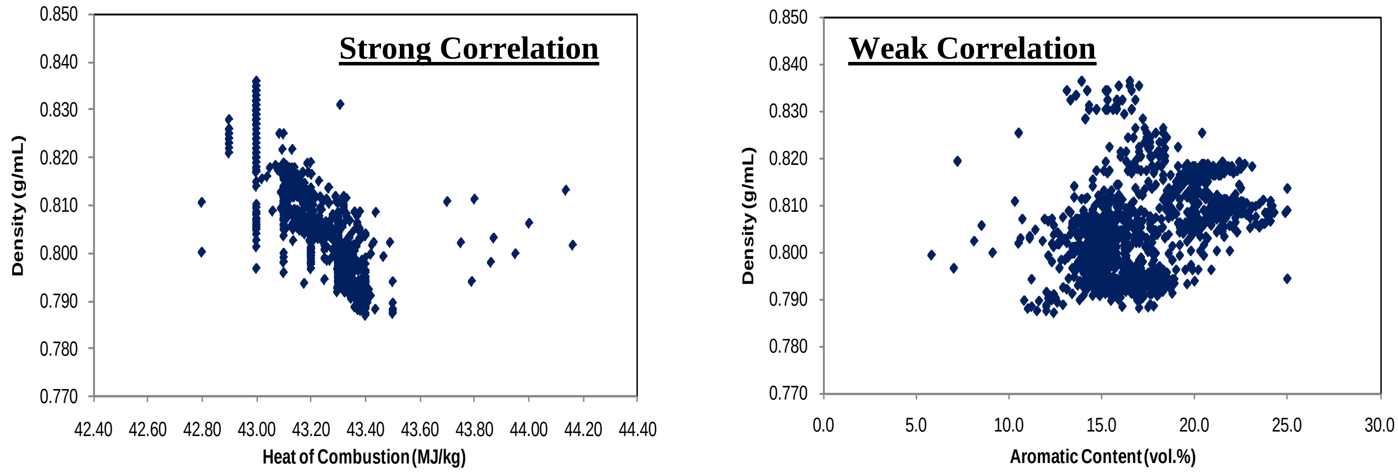

Figure 11. a-b. Plot of JP-8 Property Comparisons Based on 2008 PQIS Data from CONUS

In general, a positive correlation between fuel properties exists when there is a concurrent increase in both property values. Based on the data, there is a positive correlation between the viscosity and density, volumetric heating value (VHV) and density, and VHV and viscosity. The kinematic viscosity and density are most likely related by the corresponding chemical constituents in the fuel and normalization of the dynamic viscosity by density. The VHV and the density are related by the nature of density being used to calculate the VHV and the correlation with heat of combustion by mass shown in Figure 11. The VHV and viscosity are most likely related due to both having a positive correlation with density.

A negative correlation between fuel properties exists when an increase in one variable coincides with a decrease in another. There exists a negative correlation between the density and heat of combustion, aromatic content and heat of combustion, viscosity and heat of combustion, and the VHV and heat of combustion of JP-8 fuel. The correlation between density and heat of combustion are most likely related to the hydrogen content of the fuel (paraffinic compounds have higher hydrogen content with lower density). Likewise, the aromatic content correlation could be attributed to the same cause; however, there appears to be more scatter in the correlation. The viscosity and VHV correlations could be related to bulk chemical composition of the fuels and since the heat of combustion by mass and VHV are related linearly via density.

During comparison of the selected fuel properties, there is no recurring correlation pattern between the values of the JP-8 fuel properties for some cases. There is no distinct correlation between the freeze point and any other property considered or for the aromatic content with density, viscosity or VHV. The lack of correlations for the freeze point is reasonable since this property is primarily influenced by the long chain *n*-alkane concentration in the fuel. These components are not typically indicative of any bulk property in a fuel but rather related to the distillation range and end point during production. In addition, as discussed in the preceding sections, the fuel is only produced to satisfy the maximum freeze point (-47°C) and not typically processed further. The lack of a strong correlation between aromatic content and density was surprising, as it is typically believed that an increase in density is primarily due to the incorporation of denser aromatic compounds in exchange for less dense normal and *iso*-paraffins. However, it can be observed (Figure 11) that there must be additional chemical properties which affect these two properties in a non-linear manner. Potential explanations are the incorporation of cycloparaffins for the linear compounds or a shift to higher molecular weight compounds; these could render increases in the bulk density of the fuel without a concurrent increase in the aromatic content.

IMPLICATION OF BLENDING JP-8 WITH SPK

The recently modified Military Turbine Fuel Specification (MIL-DTL-83133F) allows for blending of up to 50% by volume of Synthetic Paraffinic Kerosene (SPK) with JP-8. In addition, the ASTM Petroleum Products and Lubricants Committee has also approved the use of SPK fuel blends for commercial aircraft (D7566 approved 5 August 09). The specifications require that the SPK must be produced via the Fischer-Tropsch (FT) process, is free of aromatics (< 1 vol. %), and has a minimum density of 0.751 g/mL. However, the JP-8/SPK blend must have a minimum aromatic content of 8.0 vol. % and density of 0.775 g/mL. Due to the nature of the SPK (lower density and aromatic-free), the addition of SPK will decrease the density and aromatic content of the blend relative to the neat JP-8. Depending on the properties of the specific JP-8, the addition of SPK can decrease the density and aromatic content below the JP-8 blend specification limits. With respect to property dependence with blend ratio, the aromatic content will vary linearly simply due to dilution theory since the mixture will behave as an ideal solution. As previously discussed, the density has also been shown to vary linearly provided the SPK has a similar volatility range to a typical aviation fuel. Understanding of the property dependence as a function of blend ratio, combined with the discrete analysis of historical JP-8 data, allows for estimation of the percentage of 50/50 vol. % fuel blends which would not satisfy the fuel specification. Discrete analysis of the historical JP-8 procurement data was performed in the following sections to calculate the probability that the minimum aromatic content or density would not be satisfied during blending with an SPK. In addition, this permits calculation of the maximum allowable blend percentage which could be used while still satisfying the fuel specification requirements.

Aromatic Content During Blending of JP-8 with SPK

Analysis was performed to calculate the percent of the total volume of fuel procured, when blended with 50 vol. % of SPK, that would not satisfy the minimum blend specification limit for aromatic content of 8.0 vol. %. This analysis was performed as a function of both year and region to attempt to identify anticipated future trends. It was assumed for this analysis that the SPK did not contain aromatic components, which is the most conservative case. Therefore, a JP-8 fuel must have a minimum aromatic content of 16.0 vol. % to satisfy the 8.0 vol. % minimum blend content. It should be noted that this analysis was performed using the discrete PQIS data; functional fits were not employed. Thus, the reported values and trends are based completely on the actual fuel properties/volumes procured from 1997-2008. The mean aromatic values shown in Figure 3 were useful in understanding general trends, but do not represent the breadth of the data (see Table 1 and Figure 4). Therefore, if the mean values are only considered, it is possible to erroneously assume that the majority of fuel blends will satisfy the blend specification since the mean values were all greater than 16.0 vol. %. Figure 12 shows the aromatic content for each individual JP-8 fuel procurement (with corresponding percent of the total volume) in CONUS for 2008. In addition, the calculated aromatic content for 50 vol. % blends of JP-8 and SPK are also shown. It is clear that a significant portion of the fuel procurement (and fuel volume) have a total aromatic content below 8.0%. More specifically, 29.8 % of the fuel procured in 2008 from CONUS has an aromatic content that falls below the minimum specification when blended with 50 vol. % of SPK. This comprises a significant portion of the total fuel procured and demonstrates considerable probability that a fuel blend would not meet the minimum specification requirement.

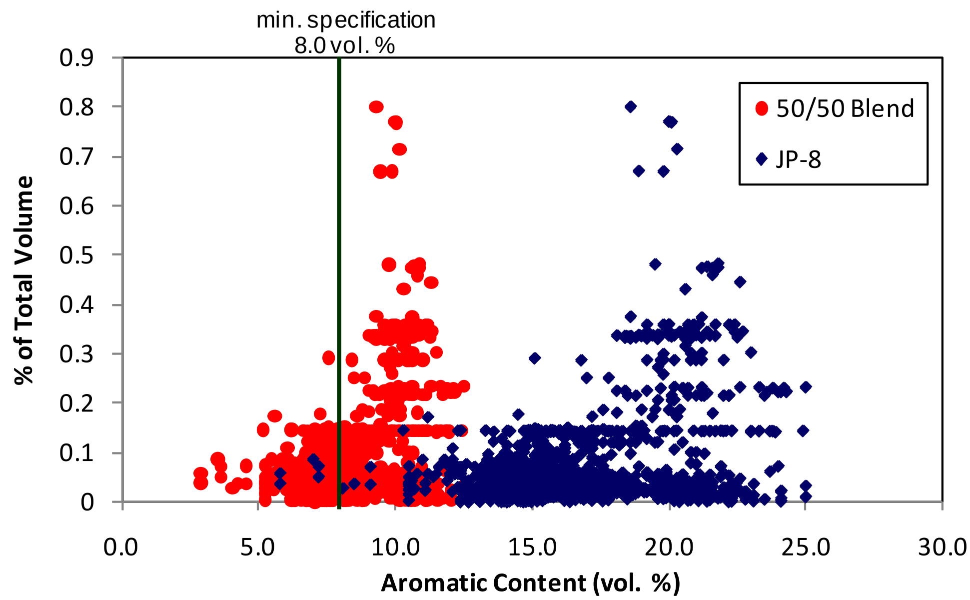

Figure 12. Aromatic Content of JP-8 and 50/50 Blend with SPK Based on 2008 PQIS Data from CONUS

Discrete analysis was performed to investigate the trends regarding the probability that 50 vol. % blends would not meet the minimum aromatic blend specification in each region within CONUS for the years 1997-2008. The comparison of the percentage of fuel volume which would be below 8.0 vol. % is shown in Figure 13. It is evident that there are significant inconsistencies in the fuel volume which would not meet the minimum content between and within each region and CONUS throughout the years. Although analysis of CONUS combined shows there is approximately a 25-35% probability of falling below 8.0%, there is a significant difference in the relative percentages in each region. Although the mean aromatic values were relatively consistent over the time considered (Figure 3), it is evident that shifts in the relative distributions has occurred leading to statistically significant variances. *Therefore, if only the trends were considered in CONUS, the probability of meeting the minimum specification requirement in each region would be significantly over-/underestimated.* Thus each region needs to be considered independently to determine the possibility that a JP-8/SPK 50/50 vol. % fuel blend from a specific region will have an aromatic content below 8.0 vol. %.

The percent of JP-8 fuel, when blended with 50 vol. % of SPK, that falls below the minimum specification limit (8.0 vol. %) is not consistent throughout all regions of CONUS. The likelihood fuel procured in Region 1 will have an aromatic content below 8.0 vol. % is statistically higher in the years 1997-2001 than in 2002-2005 and 2007. These inconsistencies are expected from the variations in the aromatic content of fuel procured in each year, as previously discussed. The procurement of one large volume batch of fuel in 2008 with an aromatic content below 16.0 vol. % accounts for the slightly higher percentage in that year. Based on the most recent historical data, approximately 10.0% (or less) of blends procured in Region 1 will not meet the specification. This is much better than the CONUS average, but the fuel in this region comprises a very small percent (< 1%) of total fuel procured. Conversely,

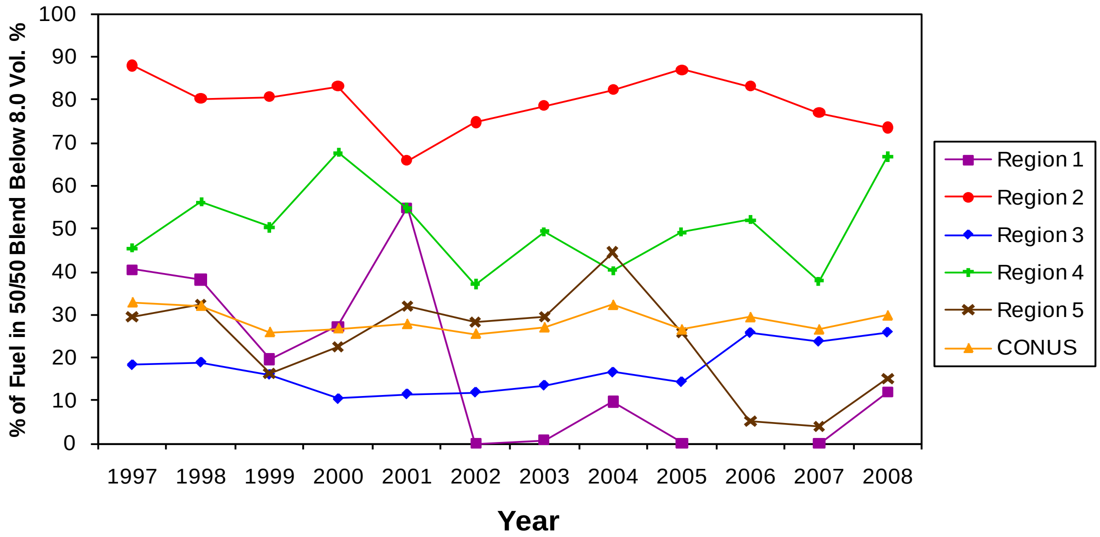

Figure 13. Percent of Fuel from 1997-2008 in 50/50 Blend with SPK with Aromatic Content Below 8.0 Vol. % for Regions of CONUS

approximately 80% of the fuel volume procured in Region 2 will have an aromatic content below 8.0 vol. % when blended with 50 vol. % of SPK. This could be extremely problematic when attempting to implement the use of SPK as a blend feedstock. Supplemental analysis performed indicated that the maximum blend percentage allowable in Region 2 to allow 95% of the fuel volume to meet 8.0% aromatic content is 23.8% (maximum blend percentages of 35.0% and 38.5% for 90 and 80% of total fuel volume to meet specification).[9] The cause of the substantially low aromatic content of fuel procured in Region 2 is not readily evident. Analysis of Region 3 indicates there is a slightly improved chance (~25%) a fuel blend will fall below 8.0% relative to COUNS, but was better (only ~15%) before 2005. This shift to lower probability is not evident when only considering the mean values (Figure 3). As expected from the inconsistencies in the range of aromatic content between the years, the percentage of fuel procured in Region 4 with aromatic content below 16.0% is not consistent. The percentage ranges from 37.9 to 67.8% throughout the years 1997-2008. Due to the procurement of differing volumes of fuel with low aromatic content between the years, there are inconsistencies in the percentage of fuel with aromatic content below 16.0%. This probability is much higher than in CONUS combined, which could be problematic during implementation. Region 5 showed a significant probability of falling below 8.0% for years 1997-2005 (~30%), but has improved substantially in recent years (~10-15%).

Based on the trends observed and analysis, a basic projection of the volume percent of fuels which would have an aromatic content below 16.0% (50% blend content below 8.0%) was made and is shown in Table 7. With the exception of Region 4, there is a relatively consistent volume of fuel within each region with an aromatic content which would not meet the minimum specification requirement when blended with SPK. The percentage in Region 4 was inconsistent throughout all years, although still higher than most of the other regions. *Therefore, consideration must be made during implementation of blending JP-8 with SPK regarding the possibility that a fuel blend will have an insufficient aromatic content to meet the minimum requirement.* Further research and development should be performed to determine if the minimum aromatic content for a fuel blend could be reduced while maintaining safe operability and satisfying all Fit-for-Purpose requirements. A lower specification limit would significantly increase the maximum allowable percentage of SPK which could be blended with a specific JP-8 and decrease the probability that a 50 vol. % blend will not satisfy the requirement.

Table 7. Trends in Percent of Fuel with Aromatic Content Below 16.0 vol. % From 1997-2008

Region	% of Fuel
1	<10.0*
2	80.0
3	20.0
4	37.9 - 67.8**
5	30.0
CONUS	30.0

* Consistent over last six years, allowing for future predictions
** Not consistent for consecutive years, cannot be predicted

Density During Blending of JP-8 with SPK

Analysis was performed to calculate the percent of the total volume of fuel procured, when blended with 50% by volume of SPK, that would not satisfy the minimum blend specification limit for density of 0.775 g/mL. This analysis was performed as a function of both year and region to attempt to determine if consistent trends exist and to identify anticipated future trends. It was assumed for this analysis that the SPK has a density of 0.751 g/mL, which is the minimum allowable density for SPK per the fuel specification (see Table A-I of MIL-DTL-83133F). Use of the minimum allowable density value allows for the most conservative estimate of the volume percentage which will not meet the required minimum blend density; SPK with a higher neat density will result in less frequency below the minimum value. In order to remain above the minimum specification limit when blending with 50 vol. % of SPK, the original JP-8 fuel must have a density of at least 0.799 g/mL. As during the discussion of the resulting aromatic content during blending, this analysis was performed using the discrete PQIS data and the reported values and trends are based completely on the actual fuel properties/volumes procured from 1997-2008. The mean density values shown in Figure 5 were useful in understanding general trends, but do not represent the breadth of the data (see Table 2 and Figure 6). Therefore, if the mean values are only considered, it is possible to erroneously assume that the majority of fuel blends will satisfy the blend specification since the mean values, with the exception of Region 1, were all greater than 0.799 g/mL.

Figure 14 shows the density value for each individual JP-8 fuel procurement in 2008 and that calculated for 50 vol. % blends of JP-8 and SPK. It can be observed that a significant portion of the fuel procurements (volume) have a density below 0.775 g/mL. In fact, 21.8% of the fuel procured in 2008 from CONUS has a density that falls below the minimum blend specification when blended with 50 vol. % of SPK. This demonstrates there is a substantial probability that the minimum blend density would not be met. It should be recalled that this is a conservative estimate and will be reduced if the SPK has a higher density; however, typical density values for SPKs investigated thus far have been shown to have values which are both higher and lower than 0.751 g/mL.[10]

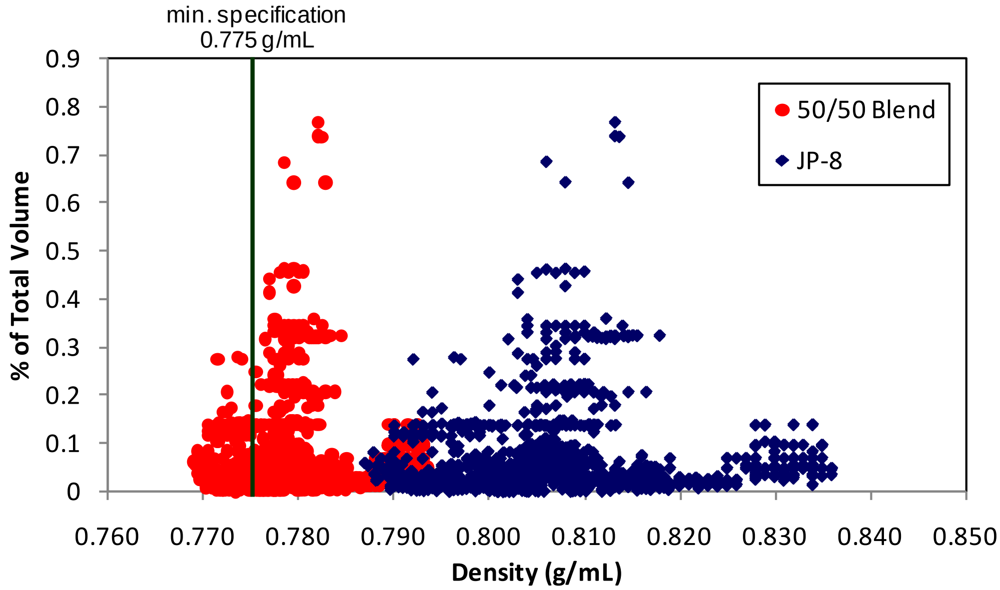

Figure 14. Density of JP-8 and 50/50 Blend with SPK Based on 2008 PQIS Data from CONUS

Discrete analysis was performed to investigate the trends regarding the probability that 50 vol. % blends would not satisfy the minimum density requirement in each CONUS region for the years 1999-2008. The comparison of the percentage of fuel volume which would not meet the 0.775 g/mL blend specification limit is shown in Figure 15. There are clear differences in the probability that a fuel blend density will be too low depending on the region in which the JP-8 was procured. In addition, with the exception of Region 5, there has been significant variability in the trends as a function of time. These results indicate that although the mean density has been relatively consistent (Figure 5), shifts in the density distributions result in statistically significant alterations in the trends. Therefore, it is required that the location of procurement be considered when attempting to determine the probability that a 50 vol. % fuel blend will meet the density specification.

The percentage of JP-8 fuel, when blended with 50 vol. % of SPK with a density of 0.751 g/mL, which will not satisfy the minimum specification limit is not consistent throughout all regions of CONUS. Region 1 showed a significant shift in recent years to almost a complete probability that the blend density will be below the minimum limit. However, as previously discussed, the total volume of fuel procured in Region 1 has been extremely low. The percentages in Region 2 and 5 are extremely low, due to the procurement of a small volumes of fuel with a density below 0.799 g/mL. This can be observed by review of the relative distributions shown in Figure 6. It is clear for Region 5 that fuels procured have a much higher relative density than in other regions, which is also shown by the much higher mean density value (Figure 5 and Table 2). The result for Region 2, especially compared to that for Region 3, is somewhat surprising considering the mean density value trends shown in Figure 5. Although the mean densities for these regions are similar, the analysis indicates that the density range is narrower for Region 2 (see Table 2). The results for Region 2 are somewhat surprising as the preceding analysis showed very high percentages of the fuels would not meet the minimum aromatic content. This further demonstrates that other fuel characteristics must more strongly affect the fuel density than aromatic content alone. Overall, fuel procured in Regions 2 and 5 will have a very high probability that the blend density will meet the minimum specification limit.

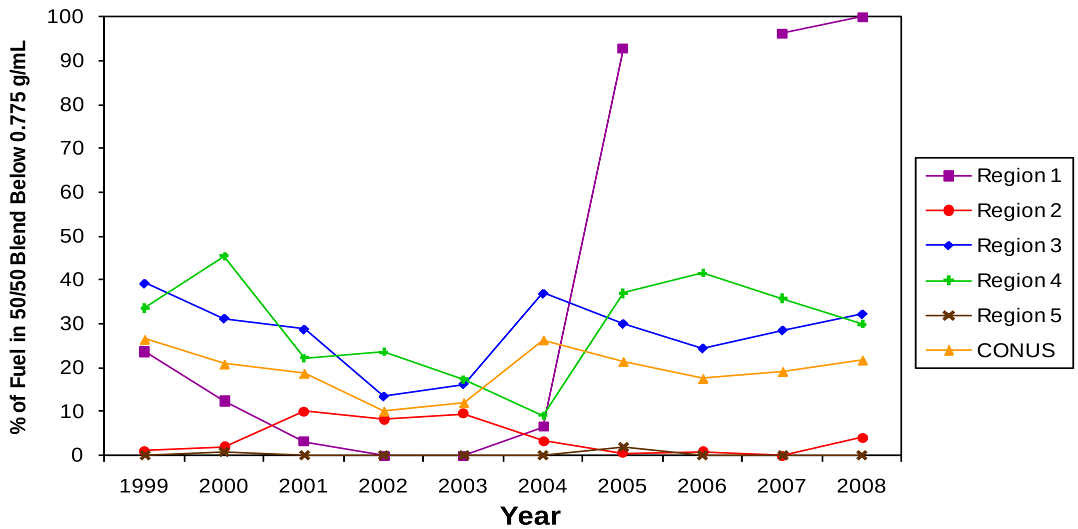

Figure 15. Percent of Fuel from 1999-2008 in 50/50 Blend with SPK with Density Below 0.775 g/mL for Regions of CONUS

Despite consistent mean densities in Region 3, the percentage of fuel with density below 0.799 g/mL has varied over recent years. The percentage is consistently about 30.0% in the years 2000-2001 and 2005-2008. However, in 1999 and 2004, the percentage is higher (approximately 40.0%) due to a lower volume of fuel with high density procured in these years. The percentages are lower in 2002 and 2003 at 13.5% and 16.3% since a lower volume of fuel was procured with a low density during these years. Based on the most recent years, the probability that a 50/50 blend from Region 3 will have a density below the minimum specification is consistently approximately 30.0%. This is higher than that for CONUS, which is approximately 20%. This higher probability is important to consider as the largest annual volume of fuel is procured in Region 3, and could result in significant chance that a fuel blend will not satisfy the minimum specification. An alternative approach is to calculate the maximum blend percentage that can be used while still meeting the specification requirement. Calculations were performed based on the 2008 PQIS data[9], these showed that the maximum blend percentages for 95, 90 and 80% of the total fuel volume to satisfy the specification limit were 38.5, 41.5, and 42.9%, respectively. These blend percentages are below the maximum allowable 50%. On the contrary, Region 5 showed much higher blend percentages, 58.6 (for 95% of fuel volume), 59.3 (90%) and 60.7% (80%), could be used while still meeting the specification. <u>This type of approach may be necessary during implementation since the minimum property specification limits must always be met.</u> The probability that the density for Region 4 will be below 0.799 g/mL has not been consistent for more than three consecutive years, and has ranged from 9.1 to 45.5%. This makes it difficult to predict the future probability that a fuel blend will not meet the minimum specification.

Based on the trends observed and analysis, an estimation of the volume percent of fuel blends which would have a density below 0.775 g/mL (using SPK with density of 0.751 g/mL) was performed and is shown in Table 8. During recent years, there is a relatively consistent volume of fuel within each region with a density which would not meet the minimum specification limit.

The percentage in Region 4, as during the aromatic analysis, was inconsistent, but higher than other regions in recent years. Region 5 showed that almost all fuels procured will meet the density requirement, but the lower density values in Region 3 result in the CONUS average of approximately 20%. *Overall, it is important to consider the region from which fuel is procured during implementation of blending with SPK when estimating the probability that a 50/50 blend will have a density below the minimum specification limit.*

Table 8. Trends in Percent of Fuel with Density Below 0.775 g/mL From 1999-2008

Region	% of Fuel
1	>90.0*
2	<10.0
3	30.0*
4	9.1 - 45.5**
5	<2.0
CONUS	20.0

* Consistent in most recent years, allowing for future predictions
** Not consistent for consecutive years, cannot be predicted

SUMMARY

Extensive research and development has recently resulted in the approval in the use of Synthetic Paraffinic Kerosene (SPK) produced via the Fischer-Tropsch (FT) as a blend feedstock with JP-8 military fuel. The JP-8 military fuel specification, MIL-DTL-83133F, currently allows blending up to 50 volume % SPK with a certification JP-8 provided the fuel blend specification limits are satisfied. Understanding of the implications of the historical variability in selected JP-8 properties helps to identify potential logistical issues during subsequent implementation. In this effort, detailed analyses were performed to investigate the historical variability of selected JP-8 fuel properties from 1997-2008 as a function of the region within the Continental United States (CONUS) in which the fuel was procured. Statistically significant differences in both the mean property values and confidence intervals were found to exist based on procurement location; these differences indicate that it will be necessary to consider each CONUS region individually when estimating the expected fuel properties during blending with SPK. Most notably, detailed analyses of the variance in the total aromatic content and density of JP-8 in CONUS showed that it will not be possible to blend all fuels to the 50 volume % maximum limit while still satisfying the 8.0 volume % aromatic content and 0.775 g/mL minimum specification requirements. This analysis provides a basis of evaluation for the implementation of alternative fuel blends and the expected maximum volume percentages which can be safely employed.

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