THE SOLUBILITY OF HYDROCARBONS IN AMINE SOLUTIONS
Supplemental Material

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1.0 INTRODUCTION

In the original paper (Carroll, et al., 1998), charts were presented for the solubility of methane in water, 15 wt% MEA, 35 wt% DEA, 50 wt% MDEA, and 50 wt% DGA™ and for ethane and propane in water and 50 wt% MDEA. In this work, the set of hydrocarbon-amine pairs is completed.

The results presented in this supplemental work should be considered preliminary because reliable experimental data are not available for these mixtures. The original paper lists the available experimental data for systems of hydrocarbons and aqueous alkanolamines.

2.0 THE MODEL

The model used here is that discussed in Carroll et al. (1998) (also see Carroll and Mather, 1997). However, reliable solubility measurements have not been obtained for ethane and propane in aqueous solutions of MEA, DEA, and DGA™. Thus, the salting-in ratios for the pairs must be estimated.

Salting-in ratios, S, which were defined in the earlier paper, were approximated in this work as follows:

$$\frac{S_{H\text{-}A}}{S_{H\text{-}MDEA}} = \frac{S_{C1\text{-}A}}{S_{C1\text{-}MDEA}}$$

where the subscript H refers to ethane or propane and A is MEA, DEA, or DGA™. Experimental data, and hence salting-in ratios, are available for the three hydrocarbons in aqueous solutions of MDEA as well as for methane in all of the amines considered in this work.

3.0 THE SOLUBILITY IN AMINE SOLUTIONS

Results are presented graphically for ethane and propane in solutions various of alkanol-amines. These charts can be used for rapid approximation of the solubility and can thus be used to estimate the loss of hydrocarbons in the stripping process.

3.1 Ethane in MEA, DEA, and DGA™

Fig. 1 shows the calculated solubility of ethane in the 15 wt% solution of MEA, Fig.2 shows ethane in 35 wt% DEA, and Fig. 3 for ethane in 50 wt% DGA™. These figures are very similar to that for ethane in pure water presented earlier. They include a small three-phase locus at low temperatures.

3.2 Propane in MEA, DEA and DGA™

Fig. 4 shows the calculated solubility of propane in the 15 wt% solution of MEA, Fig.2 shows propane in 35 wt% DEA, and Fig. 3 for propane in 50 wt% DGA™.

Again, these plots are similar to that for the solubility of propane in water. Over much of the range of temperature shown on this plot, there is a three-phase locus.

4.0 DISCUSSION

Presented in this work are charts for the solubility of two light hydrocarbons in aqueous solutions of alkanolamines. **These should be considered as preliminary since they are not based on reliable experimental data.**

These charts demonstrate the effect of pressure, temperature and the presence of the amine on the solubility. They should be useful tools for the rapid estimation of the solubility of paraffin hydrocarbons in amine solutions..

5.0 RESPONSES TO SOME QUESTIONS

Are the pressures on the graphs the "total pressures" or "partial pressures"?

They are the total pressure.

And are they "actual gallons" or "standard gallons"?

They are standard (@ 60°F) gallons.

If the hydrocarbons "salt-in" in the amine solutions, why is the low temperature solubility presented on the charts greater in water (see original paper) than in the amine solution?

When expressed in terms of SCF/100 gal, it is true that the low temperature solubility is greater in pure water. For example, in pure water at 70°F and 100 psi the solubility of ethane in pure water is about 4 SCF/100 gal (see original paper). From Fig. 1, the solubility of ethane in 15 wt% MEA is 5.7 SCF/100 gal.

First, the salting-in is the ratio of the solubilities expressed in terms of mole fraction and not in SCF/gal. The observed increase in the solubility, when expressed in the units SCF/100 gal, is due in large part to the fact that the amine solutions are more dense than pure water.

Another contributing factor is that the salting-in coefficients are increasing functions of the temperature. Therefore at low temperature, the salting-in effect is smaller than at high temperature.

Where can we get the values for the salting-in coefficients?

The salting-in coefficients are available in the papers with the raw experimental data. See the original paper (Carroll et al., 1998) for references to these papers. Several of the papers are currently in press, so please be patient. Also check the paper Carroll and Mather (1997) which more thoroughly describes the model and gives many of the parameters,

What about hydrates?

For the pure hydrocarbons in water, there is a small region (at temperatures less than about 60°F) where hydrates may form. This was a small oversight in the original paper.

The temperatures and pressures shown on the figures in this paper and in the original paper for the hydrocarbons in amine solutions are at conditions where hydrates do not form. The presence of an amine in the aqueous solution inhibits hydrate formation, similar to an ionic solid (such as sodium chloride).

Can you speculate on the solubility of BTEX in amine solutions?

It is difficult to speculate on the behavior of benzene, toluene, ethyl benzene, and xylenes (BTEX) based solely on the information in these papers. However, we expect that these components would salt-in. That is, we anticipate that the solubility of the BTEX components will be greater in the amine solution than in pure water (when expressed in terms of mole fraction). It is difficult to extrapolate from the small paraffins to the aromatics. Thus, there is a large uncertainty in predicting the magnitude of the salting-in effect.

6.0 REFERENCES

Carroll, J.J., J. Maddocks, and A.E. Mather, "The solubility of hydrocarbons in amine solutions", *48th Laurance Reid Gas Conditioning Conference*, Norman, OK, March (1998).

Carroll, J.J. and A.E. Mather, "A model for the solubility of light hydrocarbons in water and aqueous solutions of alkanolamines", *Chem. Eng. Sci.*, **52**, 545-552, (1997).

7.0 NOMENCLATURE

7.1 Symbols

S	salting-in coefficient

7.2 Subscripts

A	amine
C1	methane
H	hydrocarbon (ethane or propane)

7.3 Abbreviations

DEA	diethanolamine
DGA™	diglycolamine (diglycolamine is a registered trademark of Huntsman Corp.)
MDEA	methyldiethanolamine
MEA	monoethanolamine
SCF	standard cubic feet

Fig. 1 The Solubility of Ethane in 15 wt% MEA

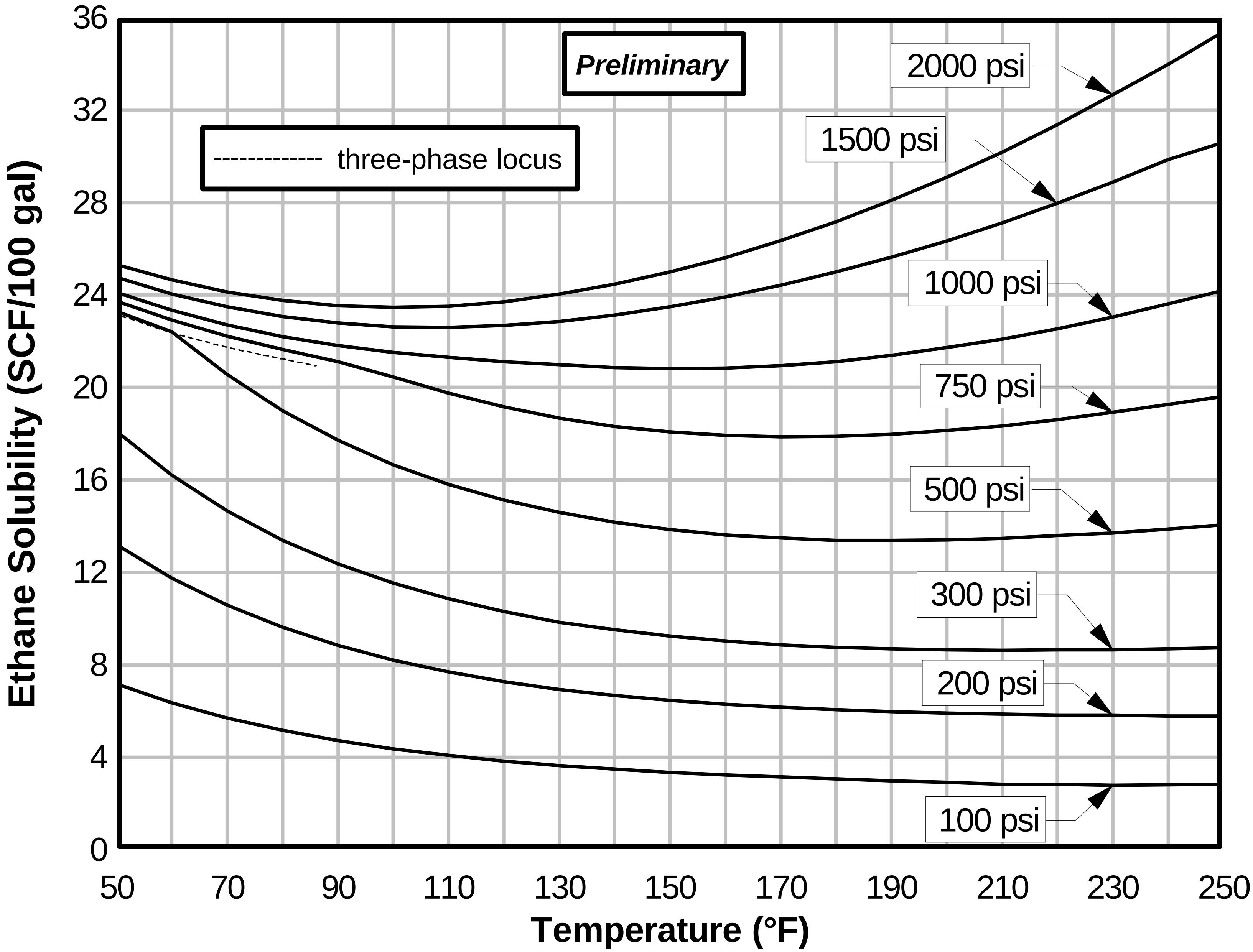
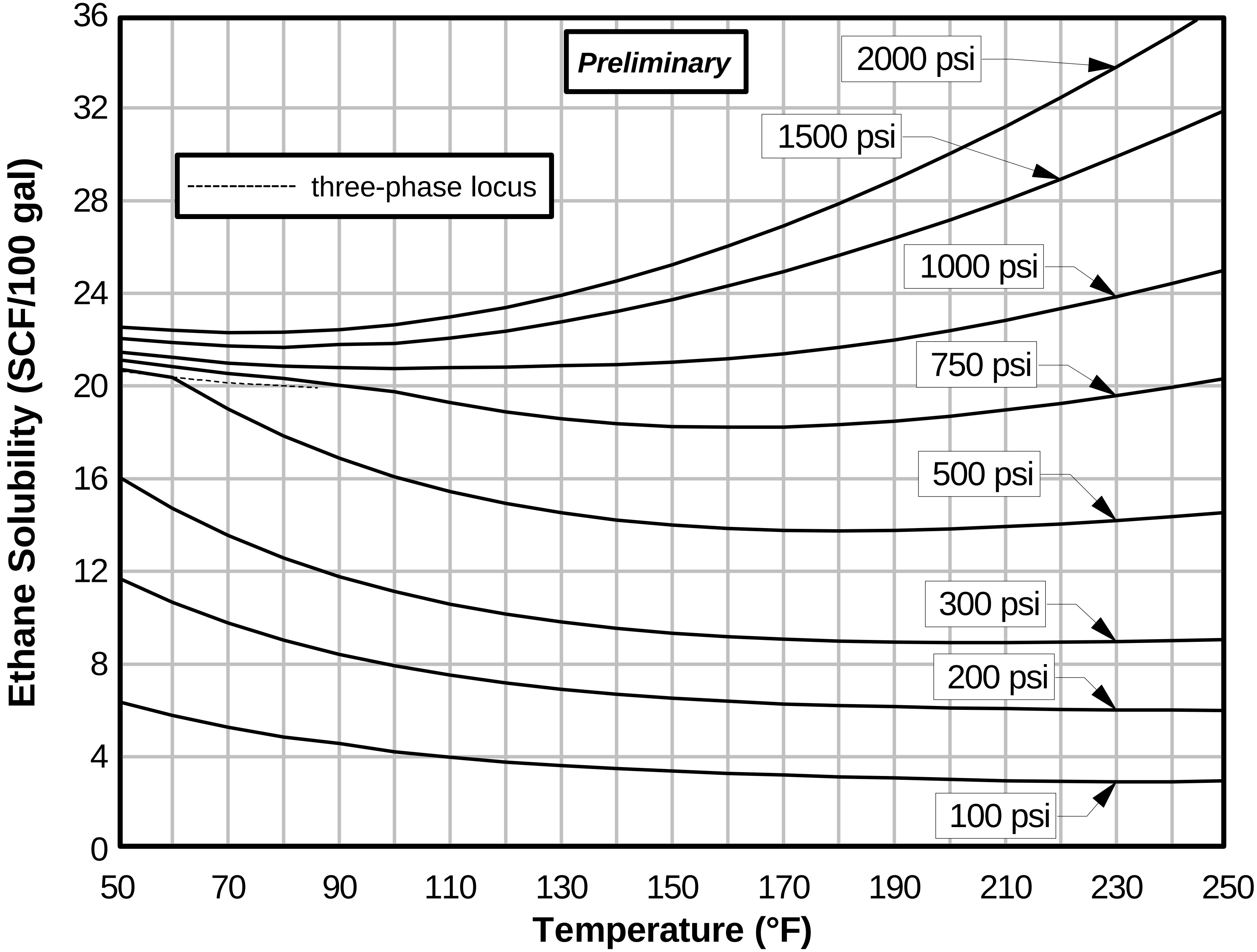


Fig. 2 The Solubility of Ethane in 35 wt% DEA



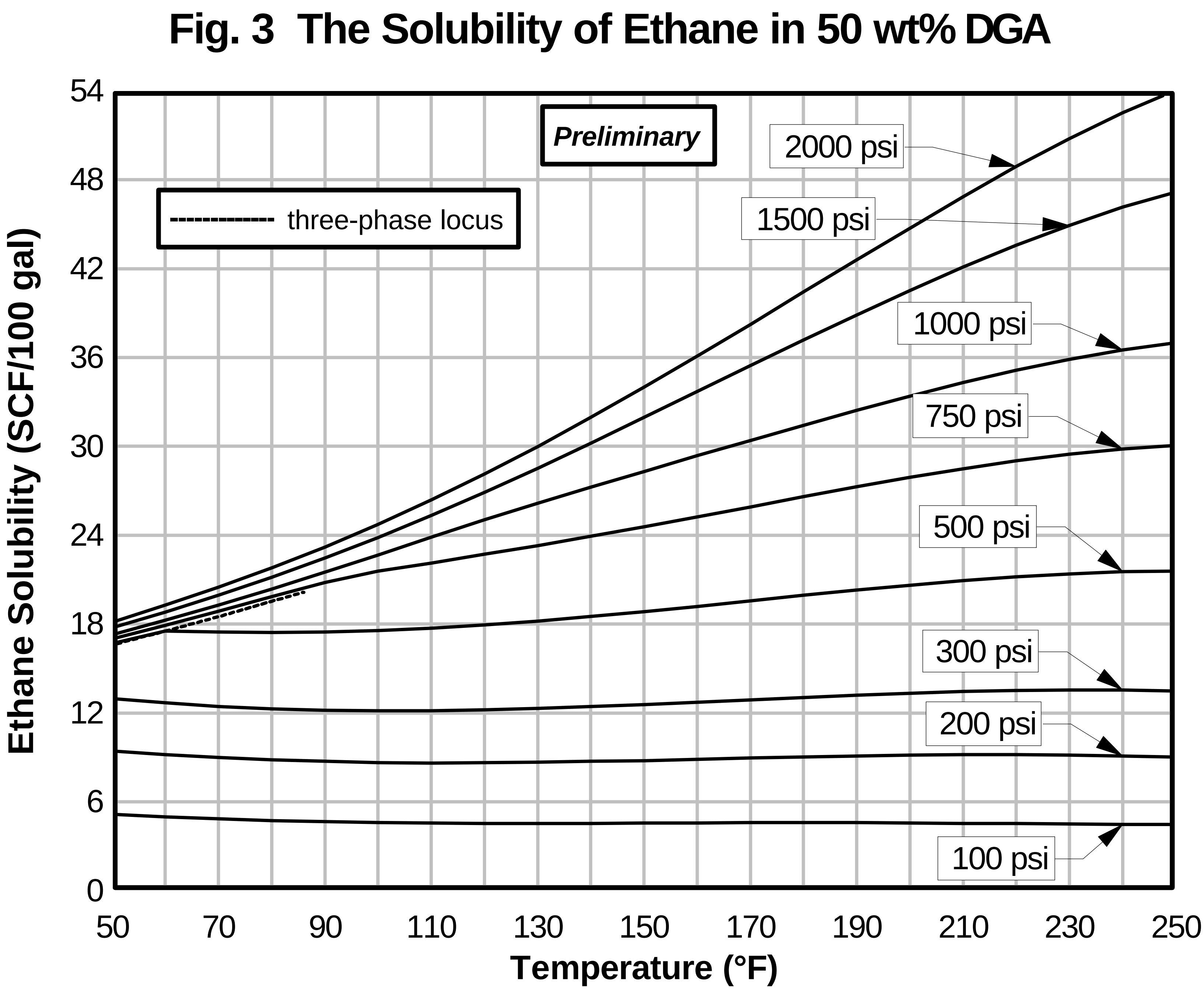


Fig. 3 The Solubility of Ethane in 50 wt% DGA
Preliminary
three-phase locus
2000 psi
1500 psi
1000 psi
750 psi
500 psi
300 psi
200 psi
100 psi
Ethane Solubility (SCF/100 gal)
Temperature (°F)
0
6
12
18
24
30
36
42
48
54
50
70
90
110
130
150
170
190
210
230
250

Fig. 4 The Solubility of Propane in 15 wt% MEA

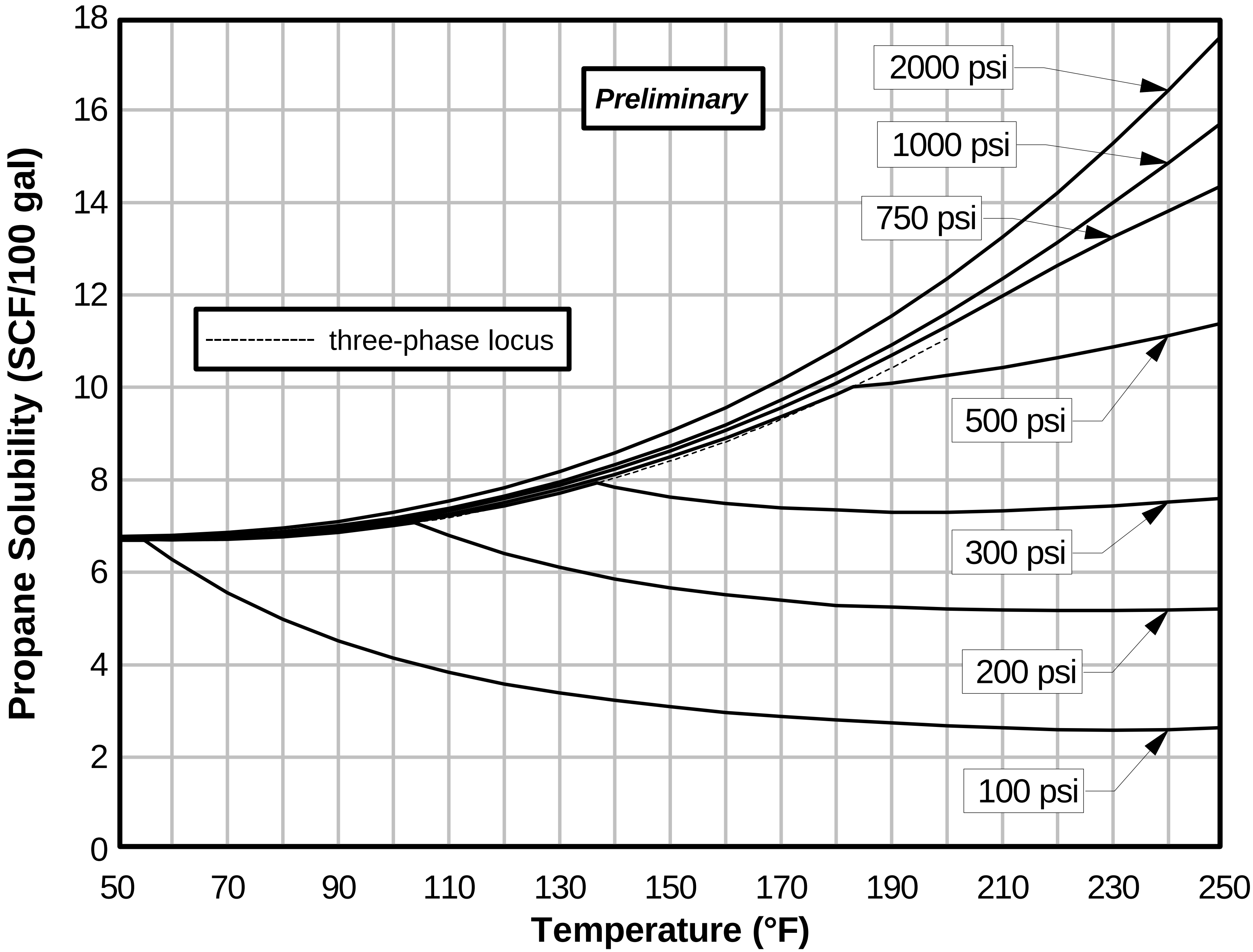


Fig. 5 The Solubility of Propane in 35 wt% DEA

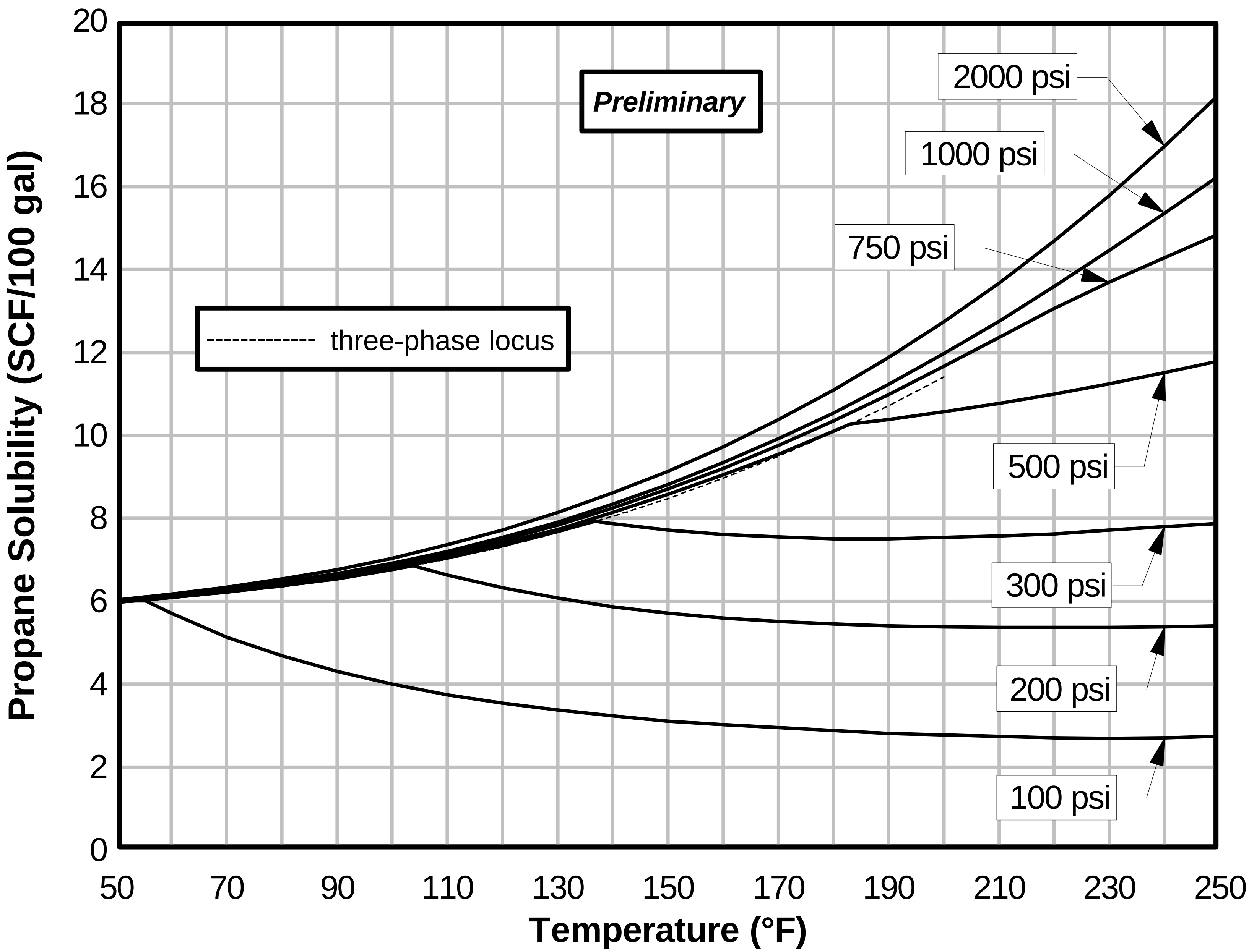


Fig. 6 The Solubility of Propane in 50 wt% DGA