Lee – Kesler Simple Fluid (Zc=0.2901) Compressibility Z factor for sub-critical Pressures with the Z-pbe equation in excel spreadsheets.

(by A.E. for myChemEngmusings.wordpress,com)

LK compressibility factors for the *sub-critical pressure* region can be directly calculated with the new " Z-pbe-LK " equation presented here. It's surprisingly compact formula can be easily entered in a single cell of an excel spreadsheet. The derivation of this Z-pbe model equation, as given in an earlier post, has here been applied to Lee–Kesler's data. This new equation matches the values in the Lee-Kesler Tables with an accuracy of 0.25% on average.

The new " Z-pbe-LK " equation reads as follows :

Z-pbe-LK = 1 - (0.329 / Tr^3.3 * Pr) / (1- 0.329/ Tr^3.3 * Pr)

and that's all.

As usual the formula is using 'excel-style' symbols for multiplication ' ***** ' and ' **^** ' for raising to the power. In the formula ' Tr ' stands for the reduced absolute temperature (T/Tc) and ' Pr ' for the reduced pressure (P/Pc). This equation yields Z factor values for the superheated vapor as well as the sub-critical vapor temperature region. In other words, this equation is valid for the following ranges: 0 < =   Pr < = 1 and   0.8 < = Tr < = 1.8 .

The " dew point – line " is the line formed by points in the " Z-pbe-LK versus Pr diagram " at whose pressure / temperature conditions (Pr,Tr point) liquid phase starts to be formed . The dew point – line intersects the isotherms, of constant Tr, to mark the edge of the " two phase liquid/vapor region ". (The dew – line is also called the " saturation line ")

The " Dew point – Line " is calculated with :

Zsat-LK = 1 - (1- 0.2901) * 0.6621 * Pr^0.667 *(1- Pr)^-0.084

This correlation equation provides the saturated Z factor value in the " Z versus Pr diagram " for the Lee-Kesler " Simple Fluid " with critical-Z factor of Zc = 0.2901.

(Note: the *form* of this Zsat equation is the same as was developed for Methane (Zc = 0.2859) that reads as follows: = 1 – (1-0.2856) * 0.666 * Pr^ 0.666 * (1-Pr)^-0.088 . And again, is also of a *similar form* for saturated steam see previous posts).
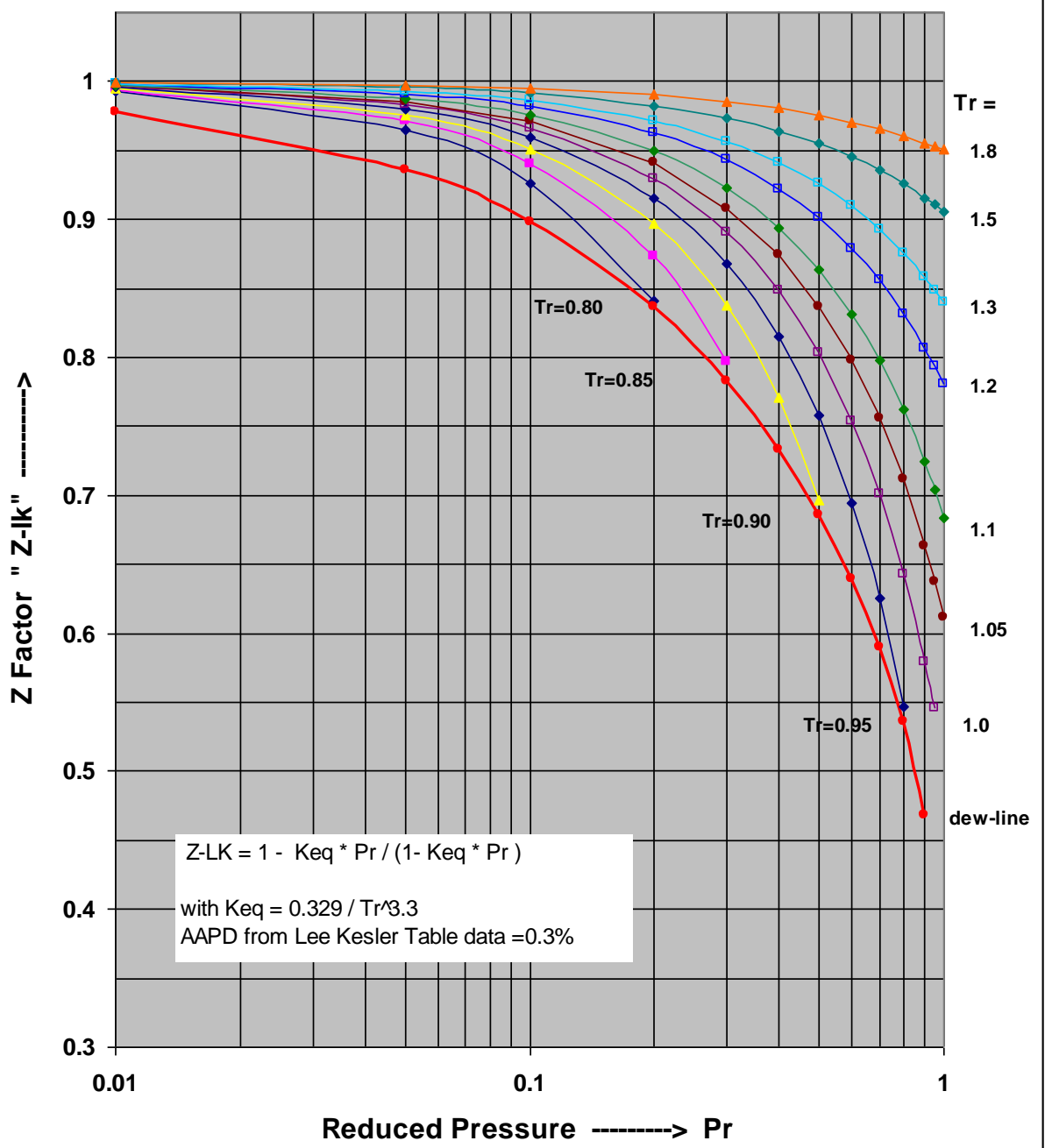
References – Links

https://onlinelibrary.wiley.com/doi/pdf/10.1002/9781118275276.app4

<u>Z-pbe-LK versus Pr Diagrams.</u> The above two equations have been plotted in an excel diagram. Two versions are shown below: one version shows Z-pbe-LK plotted against Pr on a linear scale and another one plotted against Pr on a logarithmic scale. The latter allows the low Pr range to show more clearly.
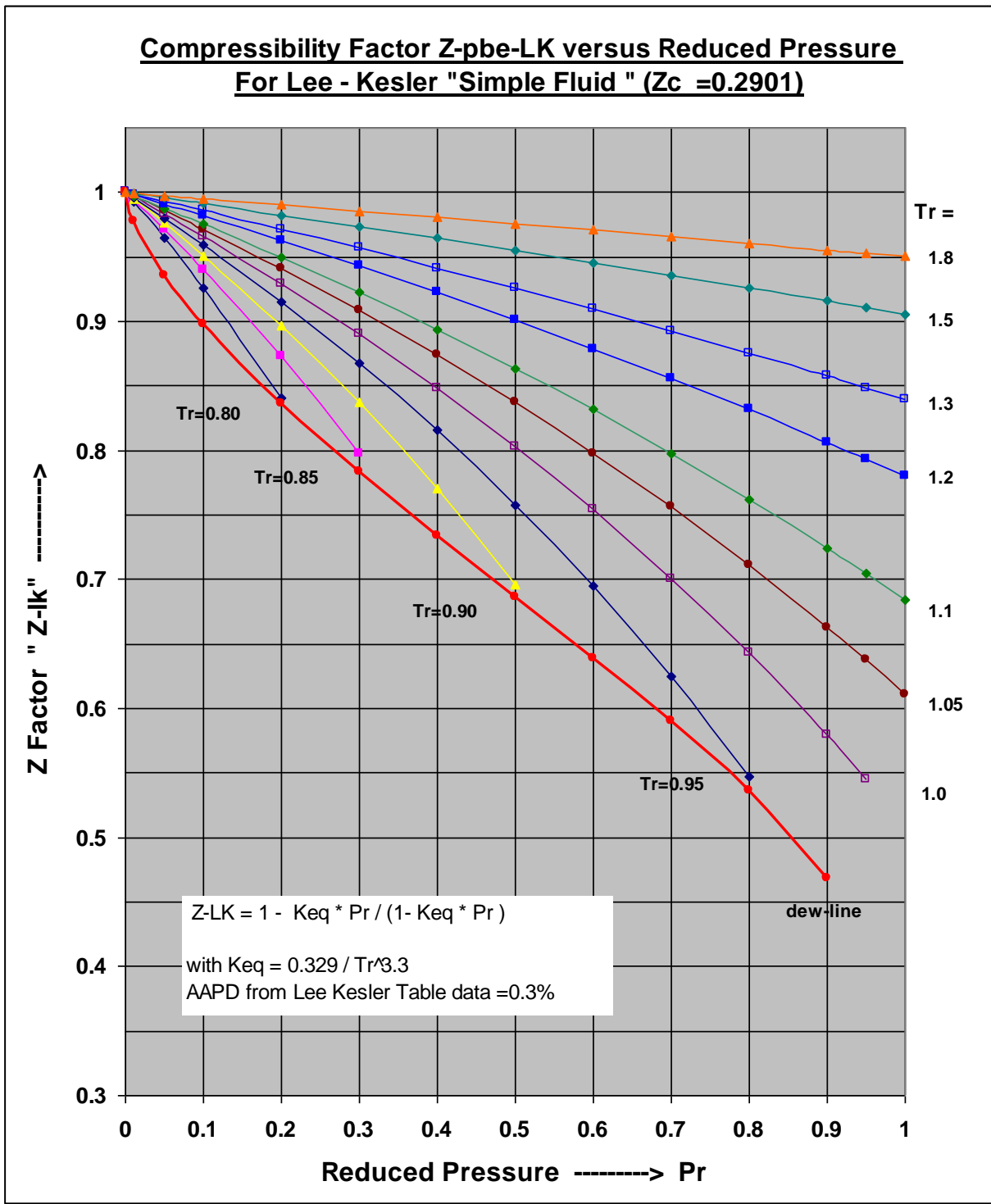
Compressibility Factor Z-pbe-LK versus Reduced Pressure
For Lee - Kesler "Simple Fluid " (Zc =0.2901)

Z-LK = 1 - Keq * Pr / (1- Keq * Pr)

with Keq = 0.329 / Tr^3.3
AAPD from Lee Kesler Table data =0.3%

Compressibility Factor Z-pbe-LK versus Reduced Pressure For Lee - Kesler "Simple Fluid " (Zc =0.2901)

Z Factor " Z-lk " ----->

Reduced Pressure ----------> Pr

Tr =

1.8

1.5

1.3

1.2

1.1

1.05

1.0

dew-line

Tr=0.80

Tr=0.85

Tr=0.90

Tr=0.95

Z-LK = 1 - Keq * Pr / (1- Keq * Pr)

with Keq = 0.329 / Tr^3.3
AAPD from Lee Kesler Table data =0.3%

Additional Notes

The dew point – line can also be derived from the Z-pbe-LK equation in combination with a vapor pressure equation, for example with Lee-Kesler 's vapor pressure correlation that requires as input the Reduced Temperature, Tr and the Acentric Factor, omega, that characterizes a substance's vapor pressure behavior !

 A 'live' spreadsheet will be made available, containing all cell formulas plus the generated two diagrams shown above plus the excel Table with Lee-Kesler data including added interpolations!

End Post =========================