BIOGRAPHY

Warren M. Ewert

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Warren Ewert is a Fellow in the Heavy Oil Division of ConocoPhillips' R&D organization, based at the Bartlesville Technology Center. Warren joined Phillips Petroleum R&D in Bartlesville in 1979 and has 30 years of experience in chemical and refining pilot plant scale process development and commercialization, including the Chevron Phillips Chemical selective ethylene-to-hexene-1 process that won the 2005 Kirkpatrick Chemical Engineering Achievement Award and the ConocoPhillips S Zorb Sulfur Removal Technology. He has B.S. and M.S. degrees in chemical engineering from Kansas State University and an M.S. degree in chemistry from Oklahoma State University. Warren is a registered professional engineer in the state of Oklahoma and is a member of the National and Oklahoma Societies of Professional Engineers, the American Institute of Chemical Engineers, and the American Chemical Society. He and his wife, Joleen, have been married for 29 years and have four daughters, ages 23, 20, 18, and 13.

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ABSTRACT

API Gravity and Viscosity of Residues from Conventional and Bitumen-Containing Crude Oils

Warren M. Ewert and Chris Lewis

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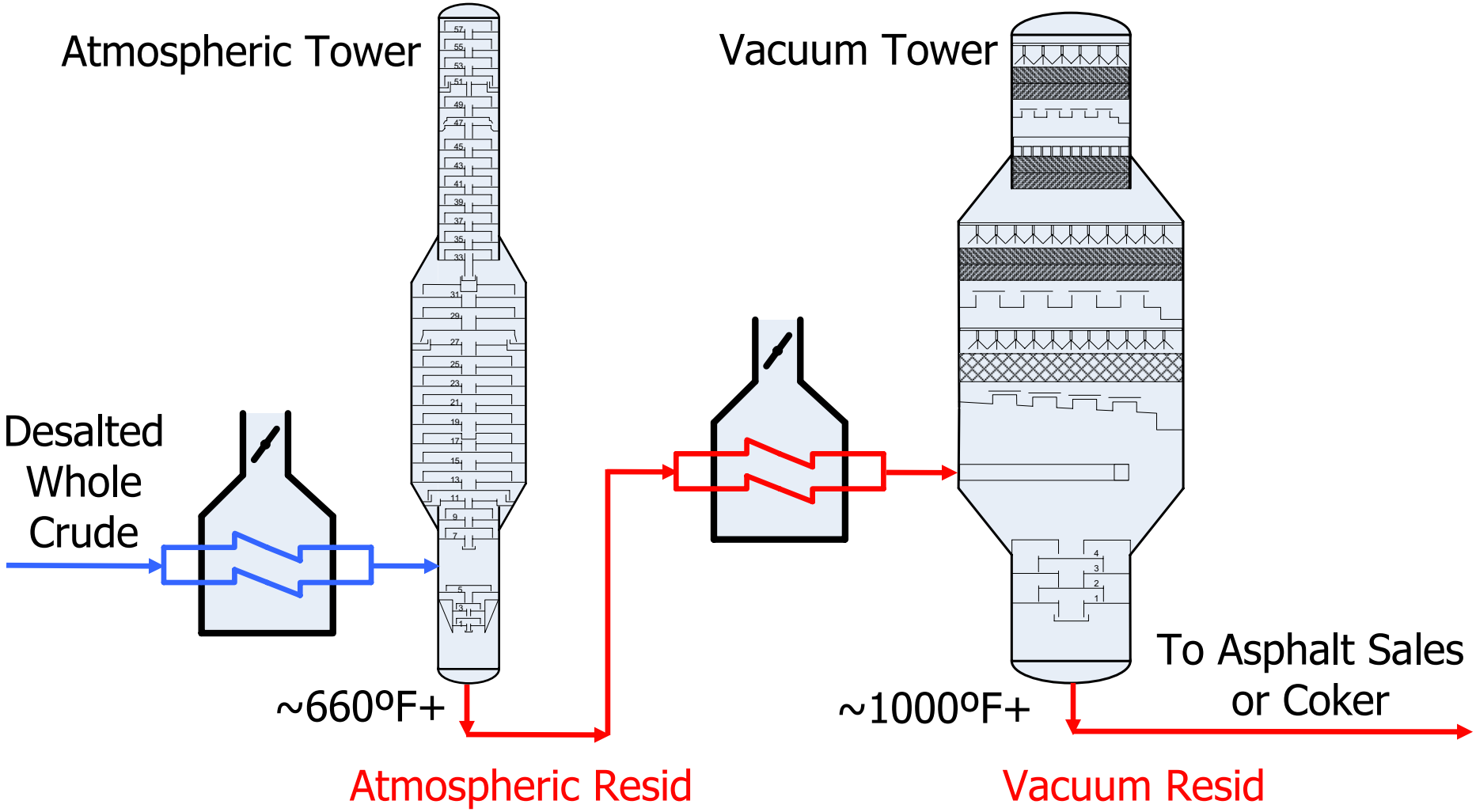
API gravity and viscosity are two key properties of atmospheric and vacuum residues that refiners must consider when replacing conventional crude oils with bitumen-containing crudes. Crude oil assays are commonly used to estimate residue yields and properties, but results from different laboratories can vary significantly. This presentation will demonstrate that high-temperature simulated distillation analysis of the assay residues provides a convenient way to reconcile data from multiple samples and different sources. It will also show that this methodology allows comparisons between different types of crude oil residues to be made on a consistent cut point temperature basis.

API Gravity and Viscosity of Residues from Conventional and Bitumen-Containing Crude Oils

Warren Ewert and Chris Lewis
Research & Development, Bartlesville, OK

Presented at the 5th NCUT Upgrading and Refining Conference 2009, Edmonton, Alberta, Canada. September 14-16, 2009

Residue Yields and Properties are Important to Refiners



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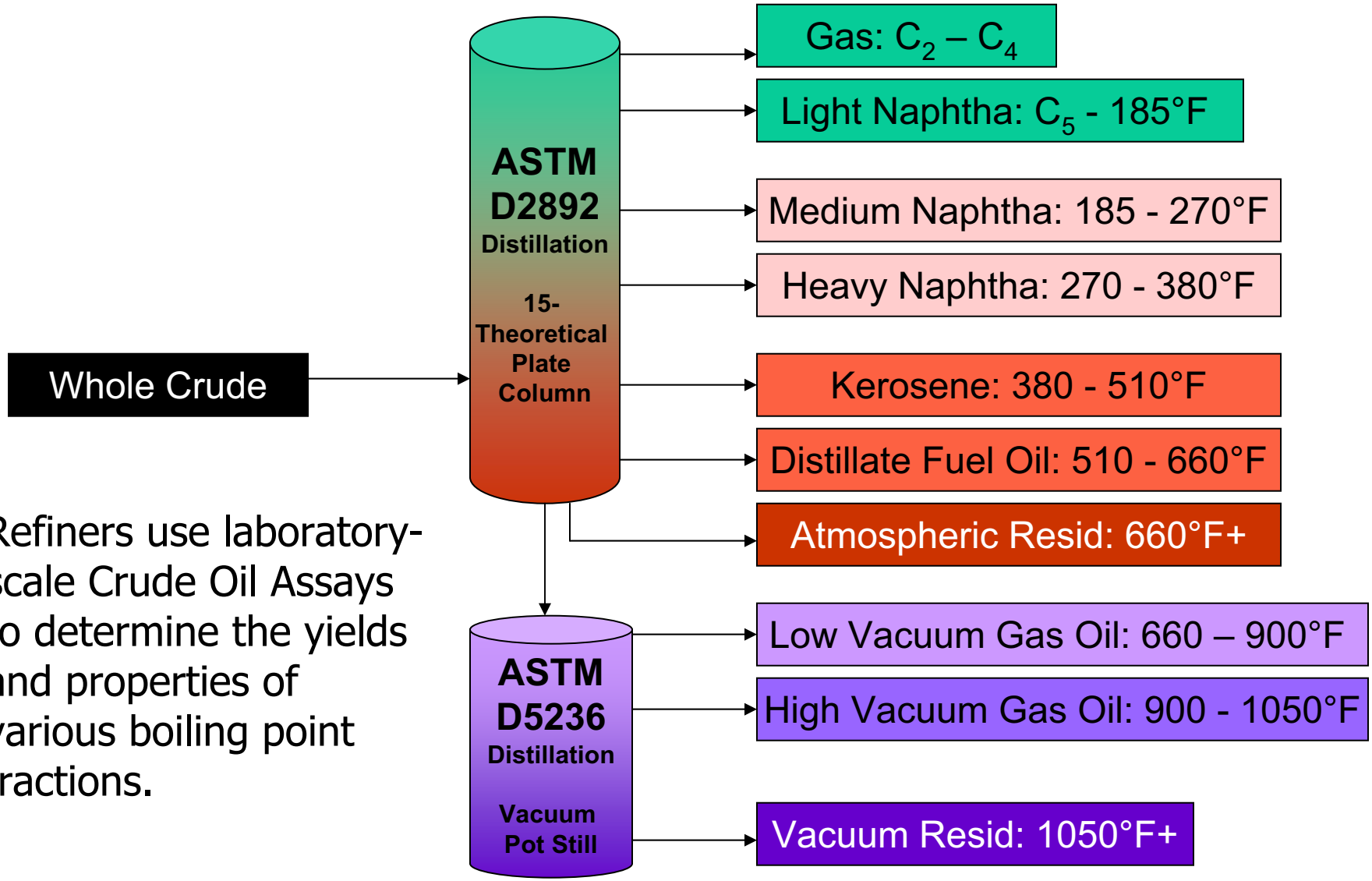
Resid Density and Viscosity Issues

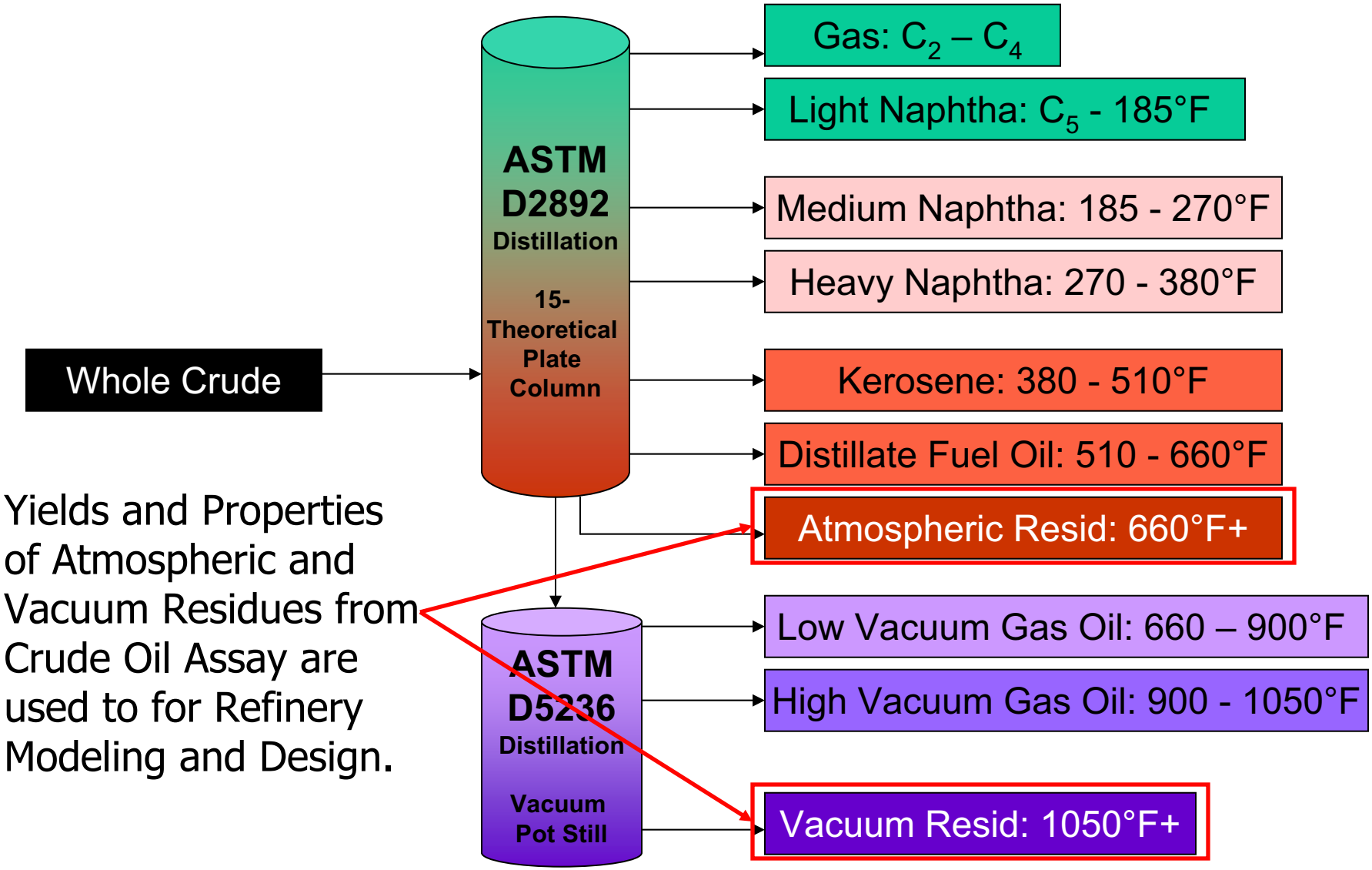
- Resid density and viscosity are important for designing and operating refinery transfer line systems
- Vacuum resid viscosity is a key performance characteristic of asphalt
- Vacuum resid density (API gravity) is an important characterization parameter for predicting coker performance
- Resid cut point is an important operating parameter, impacting yield and vacuum tower and coker design
- Refinery crude slate changes potentially impact resid properties and yields
- Reported resid properties differ from assay to assay for the same crude, creating a potential dilemma for refiners

Crude Oil Assay



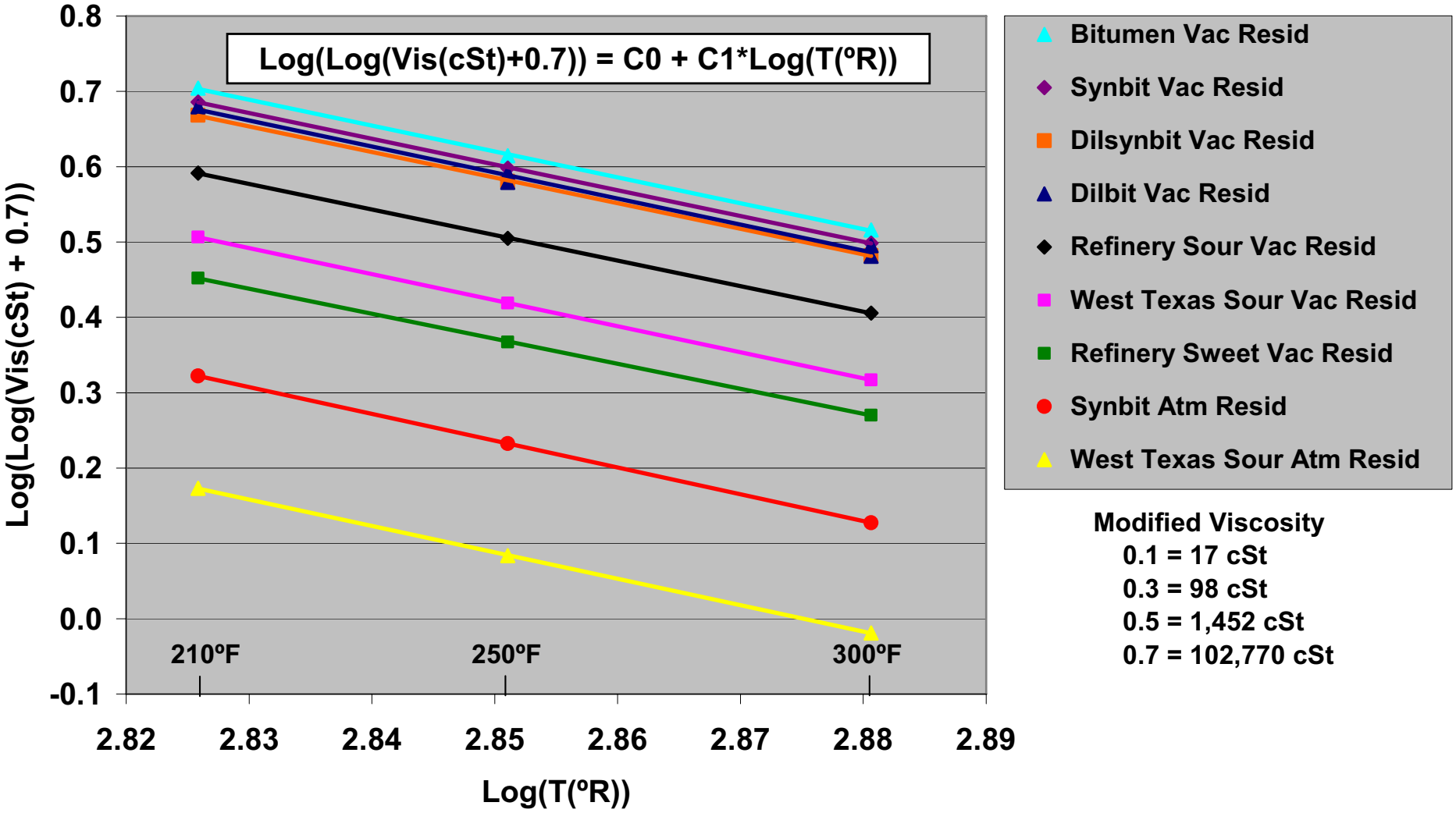
Refiners use laboratory-scale Crude Oil Assays to determine the yields and properties of various boiling point fractions.

Crude Oil Assay - Source for Resid Information



Yields and Properties of Atmospheric and Vacuum Residues from Crude Oil Assay are used to for Refinery Modeling and Design.

Resid Viscosity Can Be Linearized as a Function of Temperature Using the Method Outlined in ASTM D 341



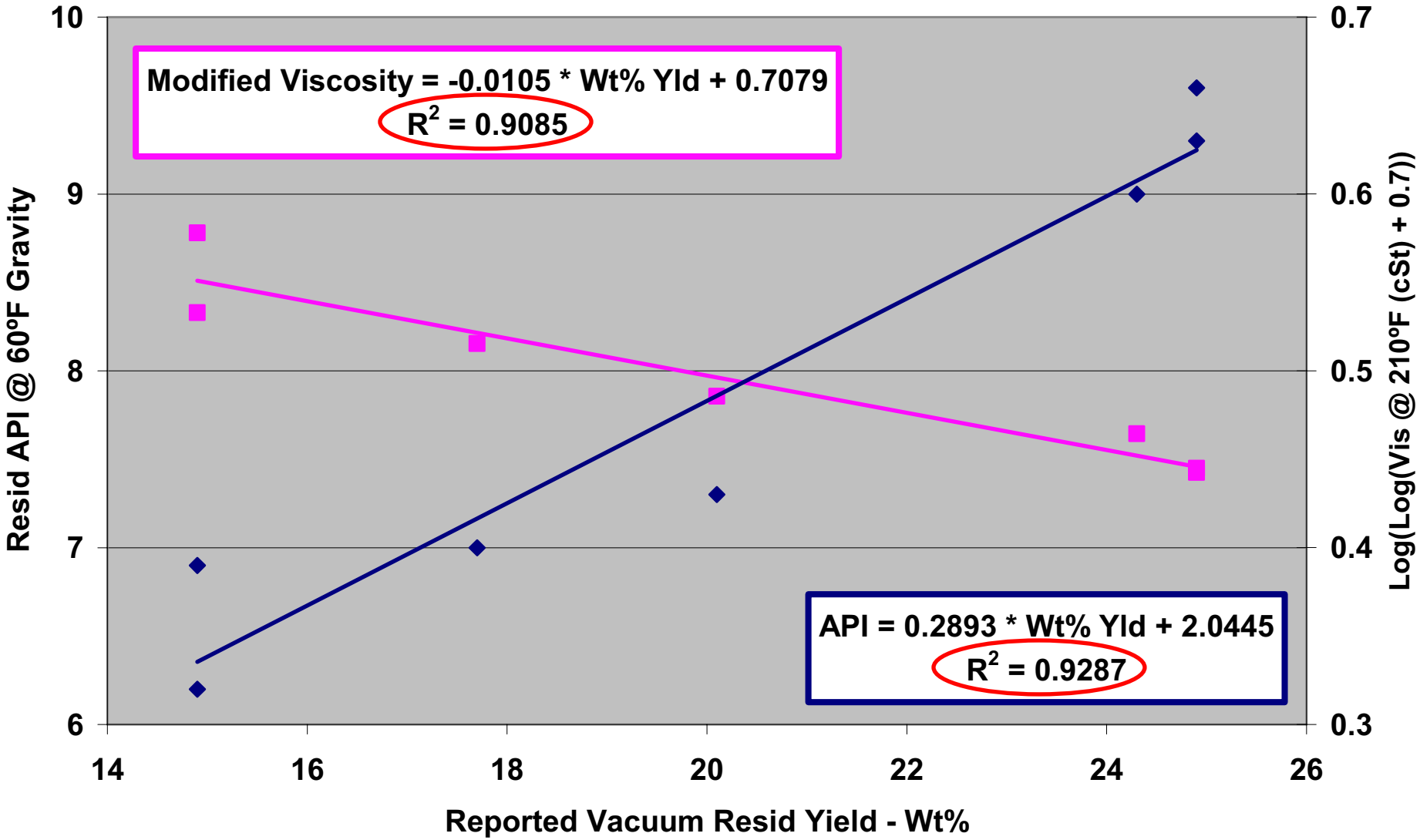
Modified Viscosity
- 0.1 = 17 cSt
- 0.3 = 98 cSt
- 0.5 = 1,452 cSt
- 0.7 = 102,770 cSt

Variability in Vacuum Resid Yields and Properties from Different Assays – Which Values are "Correct"?

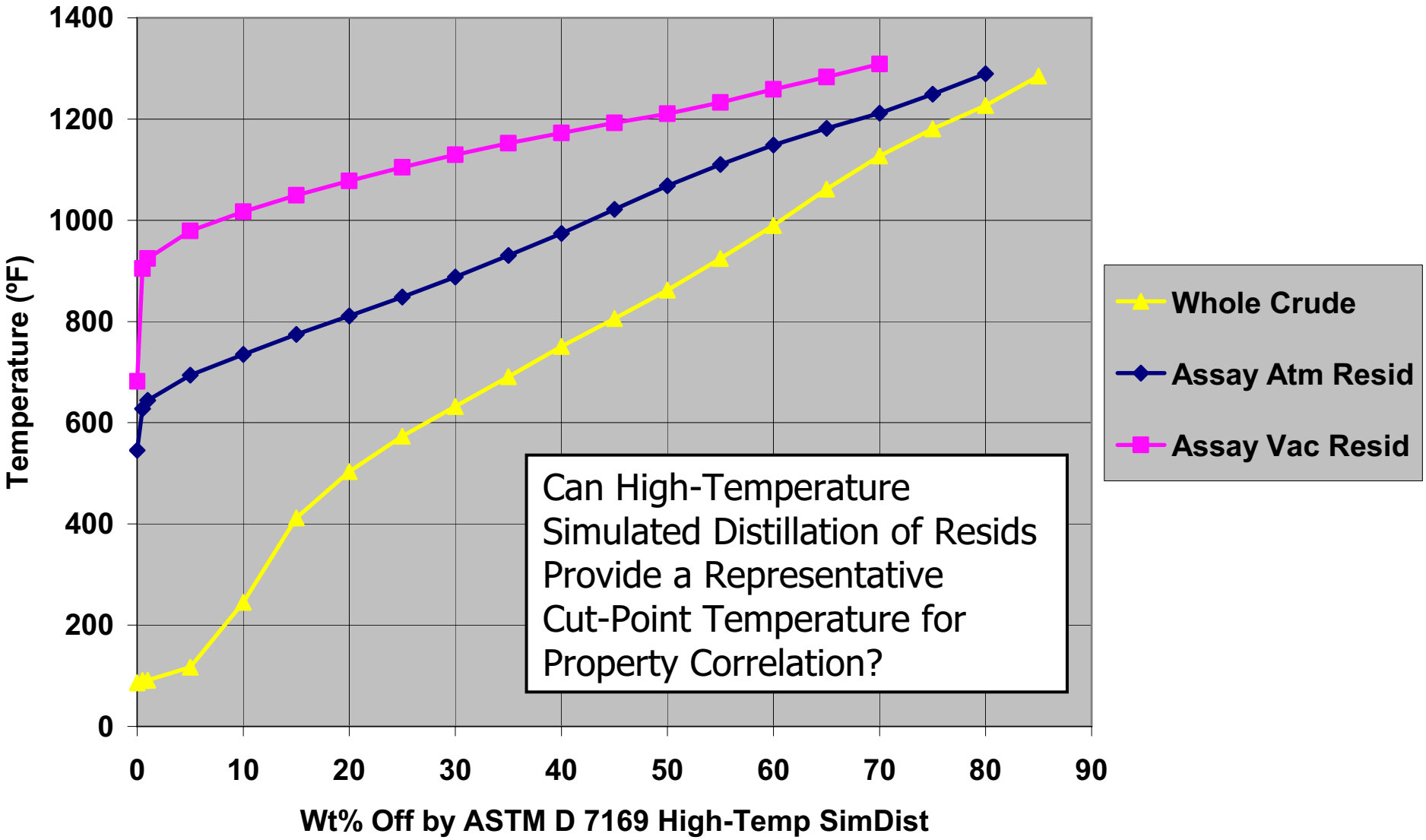
Reported Resid Cut Point (ºF)	Vac Resid Yield - Wt % of Whole Crude	Vac Resid API Gravity @ 60ºF	Vac Resid Viscosity @ 210ºF (cSt)
1022	20.1	7.3	1145
1050	24.9	9.3	609
1050	24.3	9.0	818
1050	24.9	9.6	589
1100	17.7	7.0	1888
1100	14.9	6.9	2576
1100	14.9	6.2	6098

Resid yield, gravity, and viscosity do not correlate well with reported cut point.
(r^2 values for linear correlations with cut point temperature = 0.39 to 0.58)

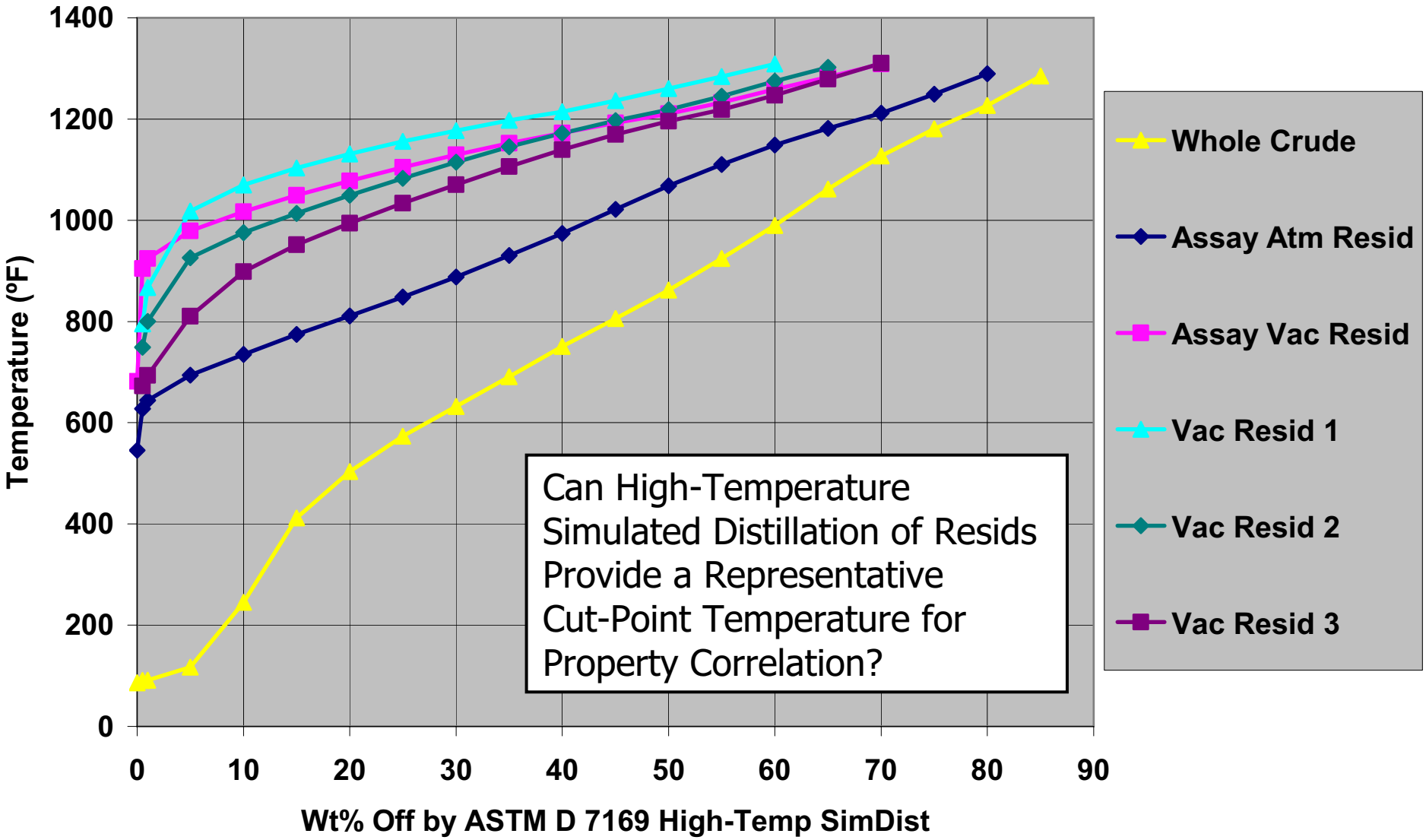
Vacuum Residue API Gravity and Modified Viscosity are Well-Correlated with Yield



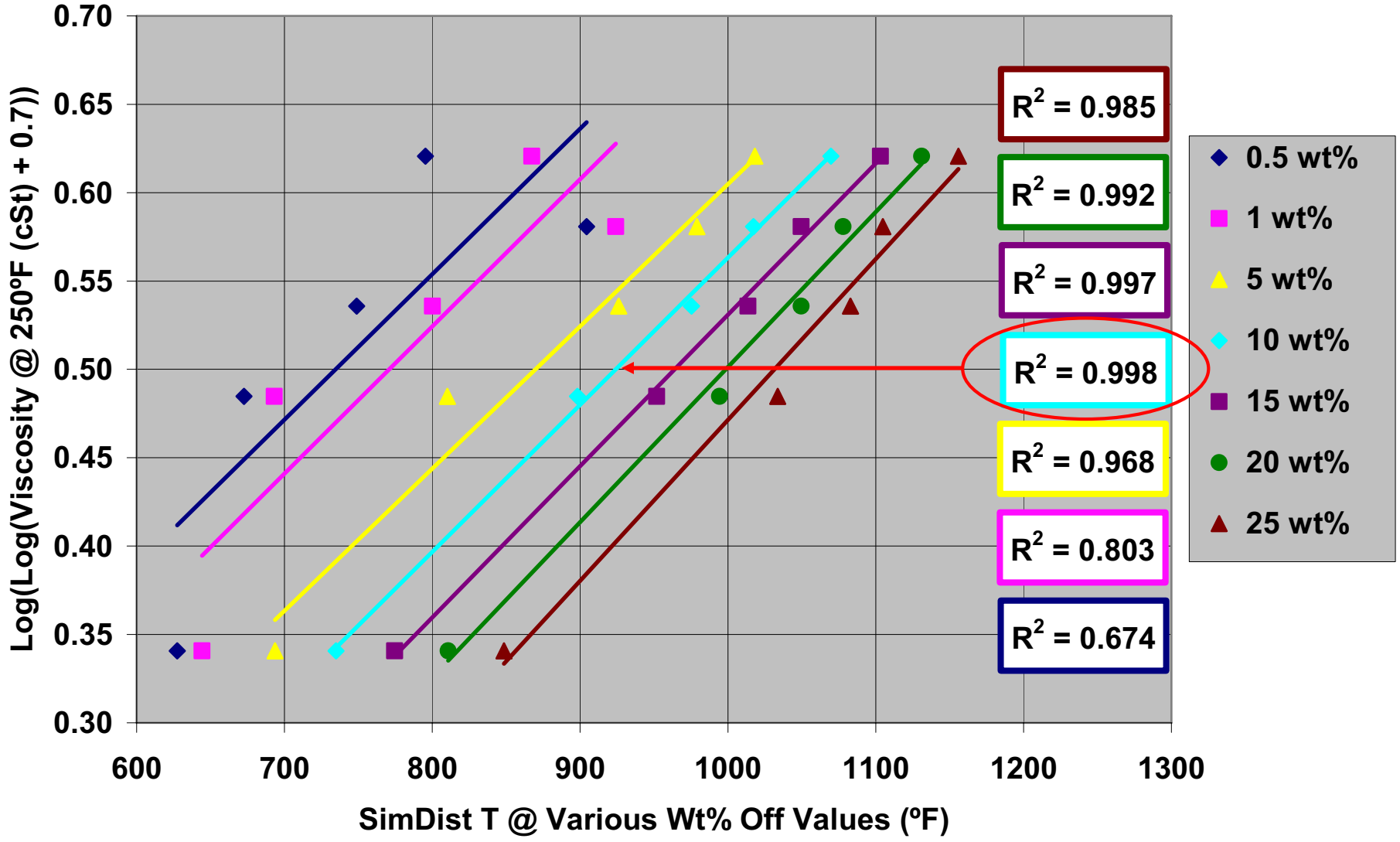
Dilsynbit Whole Crude and Resids



Dilsynbit Whole Crude and Resids



T(10 wt%) Temperature from High-Temperature SimDist Correlates Well with Dilsynbit Resid Modified Viscosity



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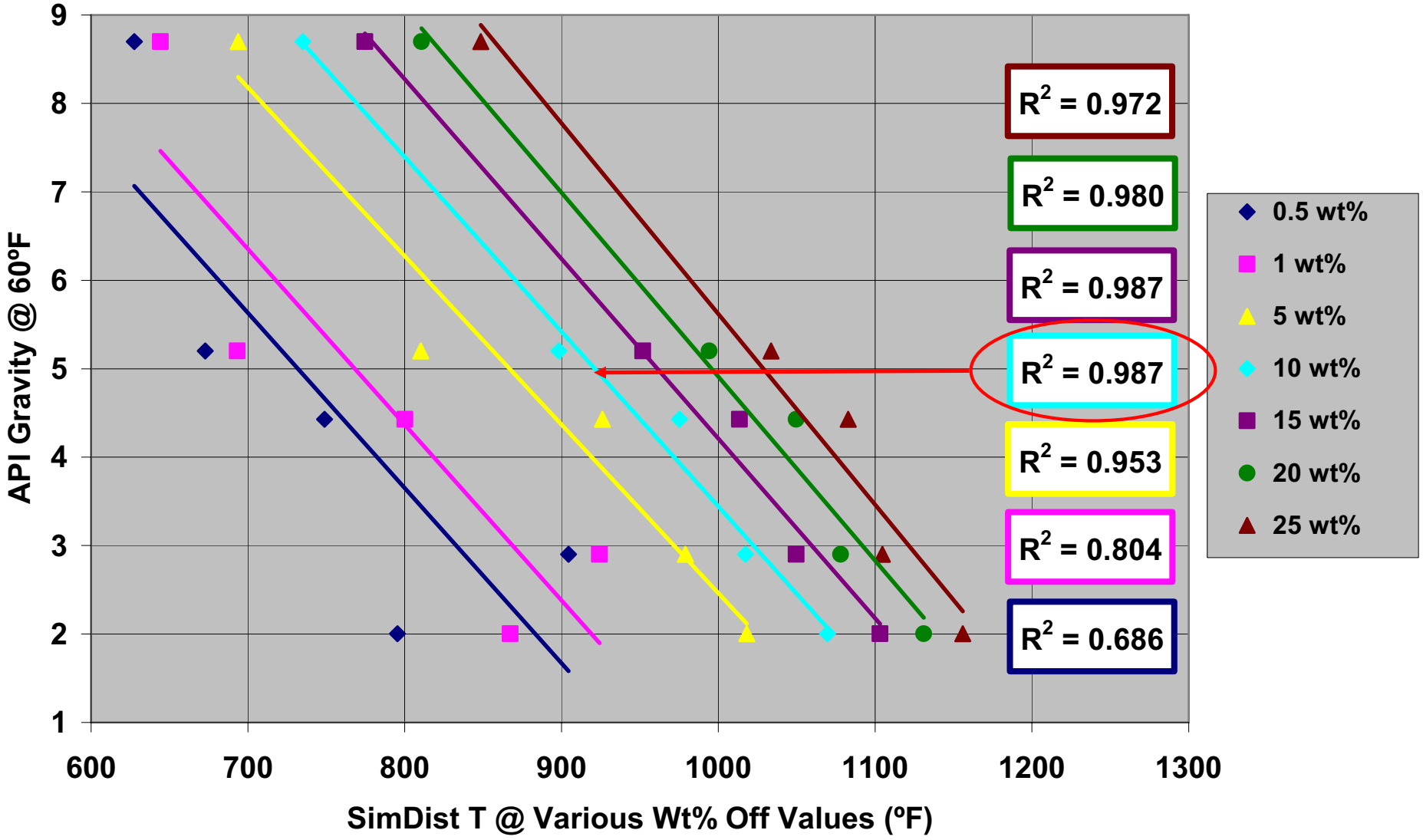
T(10 wt%) Temperature from High-Temperature SimDist Correlates Well with Dilsynbit Resid API Gravity



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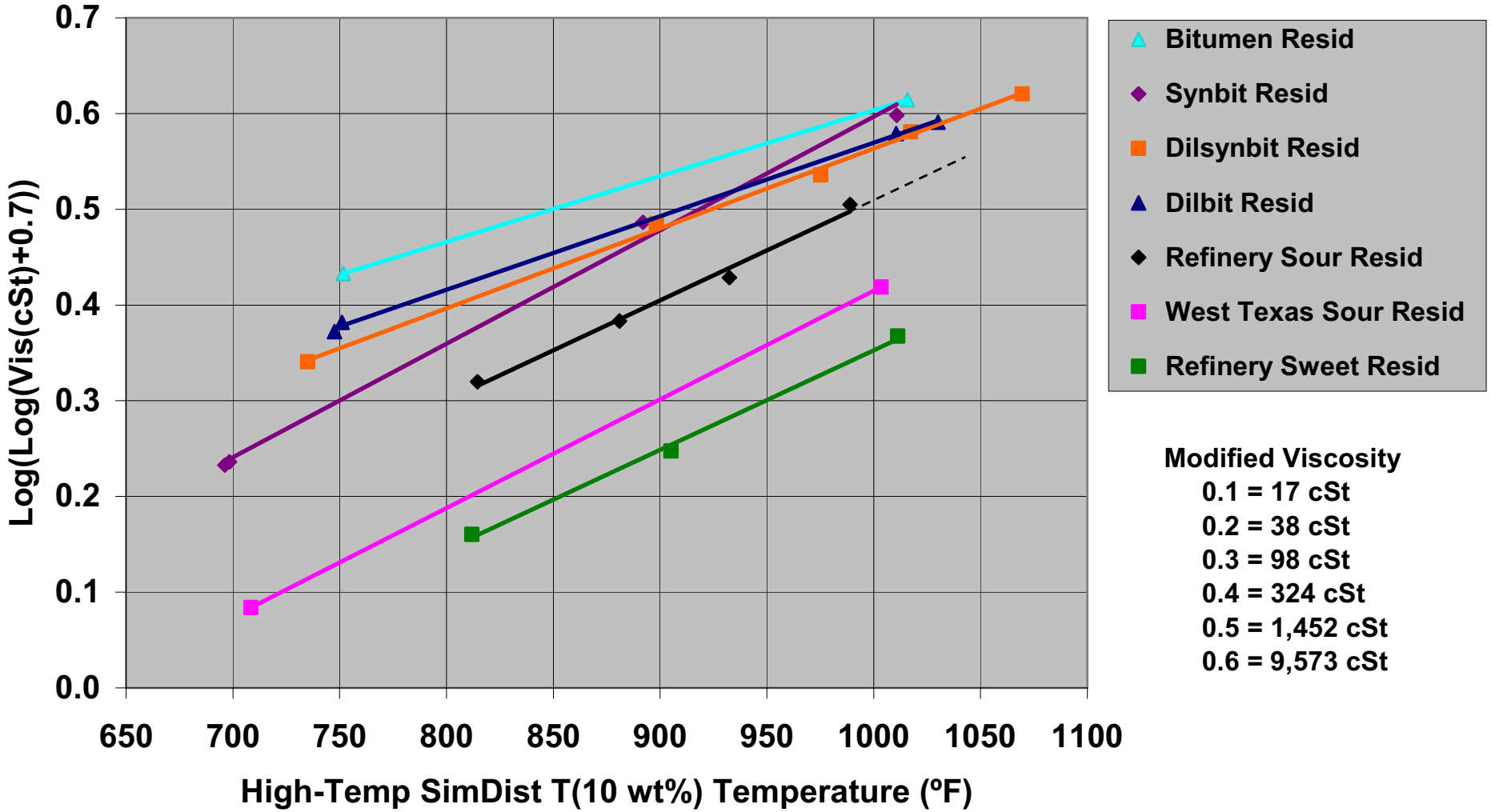
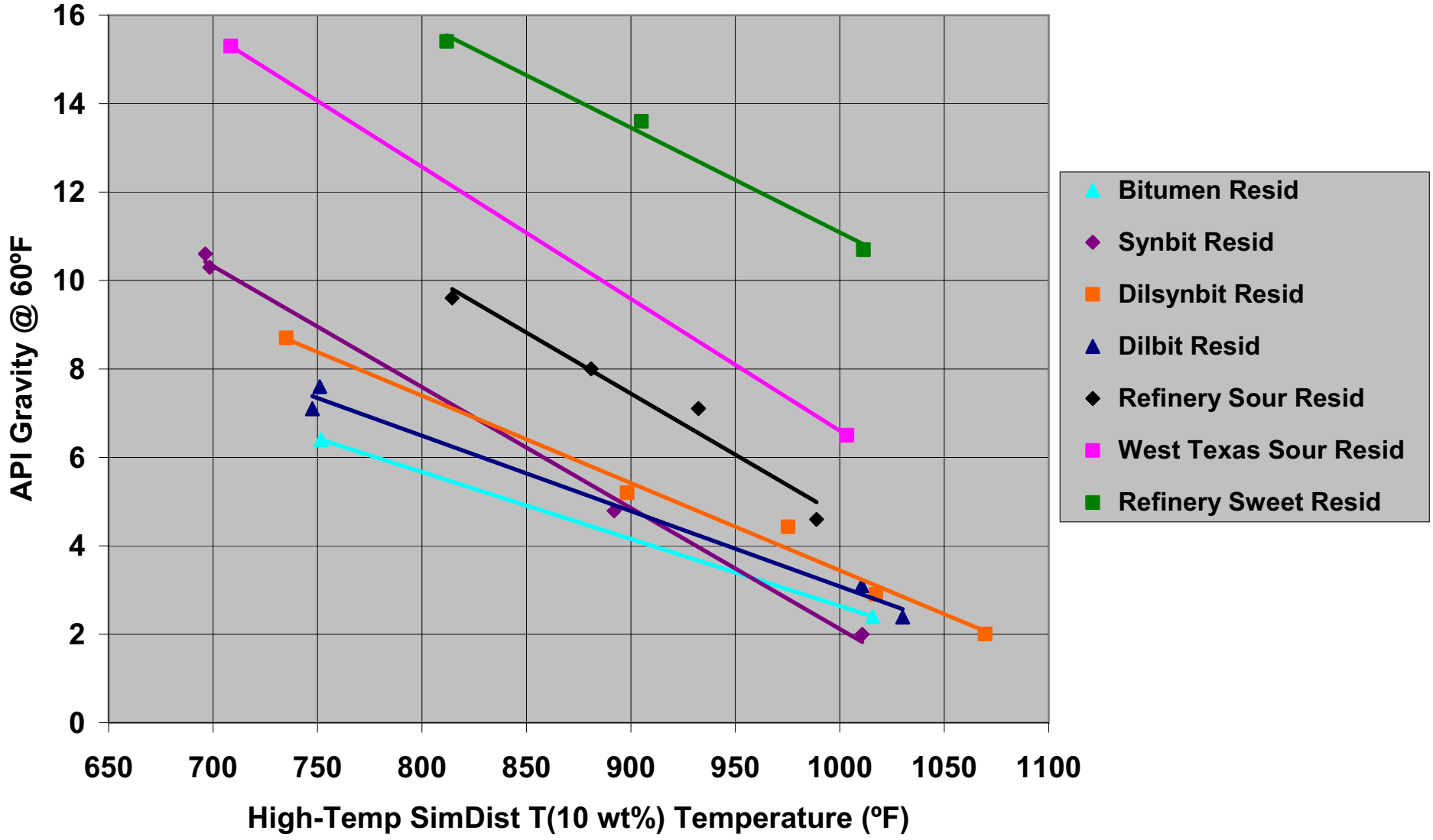
Modified Viscosity @ 250ºF for Resids from Conventional and Bitumen-Containing Crudes vs. T(10 wt%) HT SimDist Temperature



API Gravity @ 60ºF for Resids from Conventional and Bitumen-Containing Crudes vs. T(10 wt%) HT SimDist Temperature



Modeling Resid Density and Viscosity

- Resid viscosity can be predicted as a function of sample temperature and cut point using the T(10 wt%) temperature from high-temp SimDist

$$Log(Log(Vis(cSt)+0.7)) = C0 + C1 \times Log(T(^{o}R)) + C2 \times T(10wt\%)$$

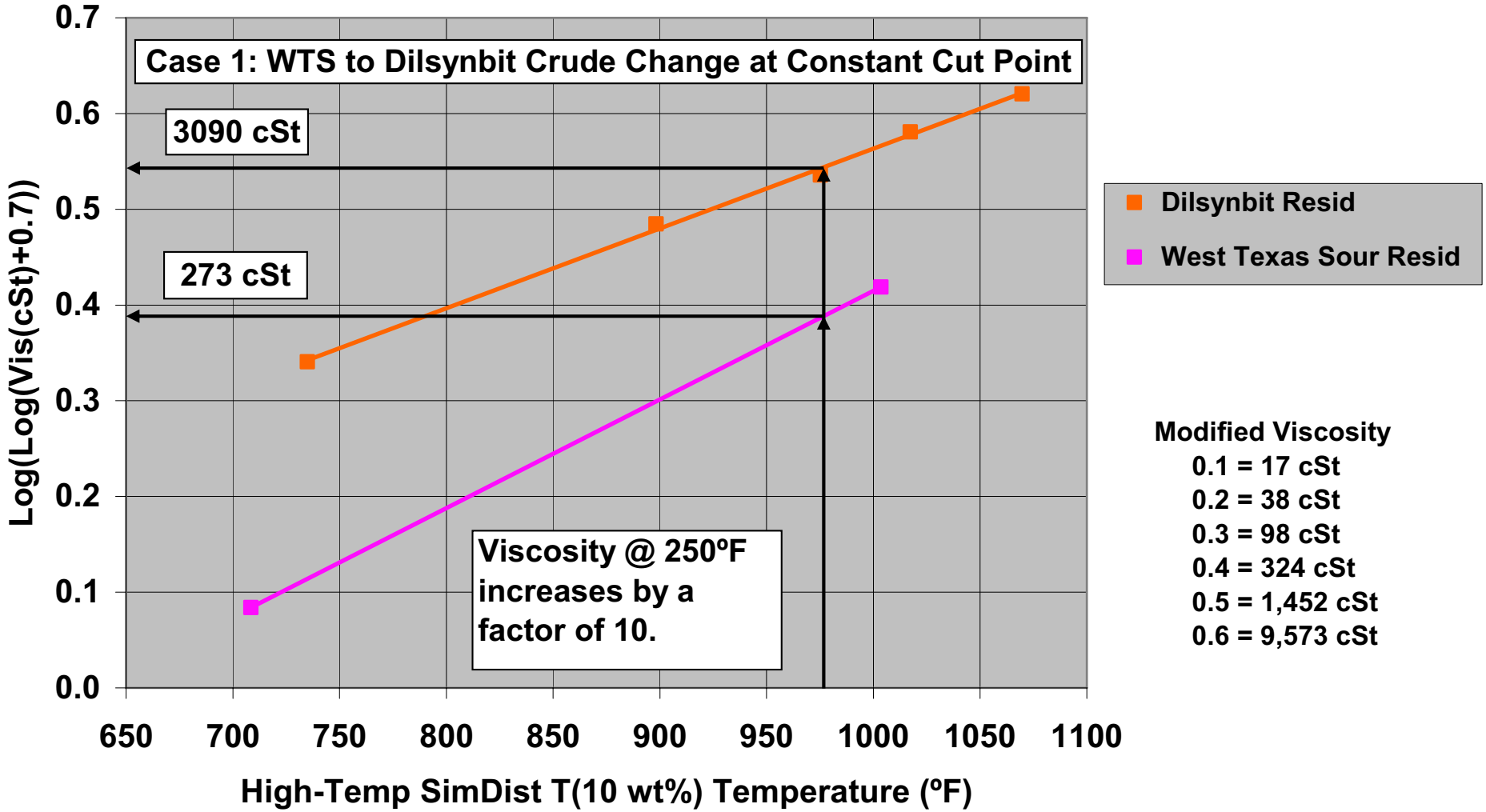
- Resid density (API gravity) can be predicted as a function of cut point

$$API = C0 + C1 \times T(10wt\%)$$

"What If" Scenario #1

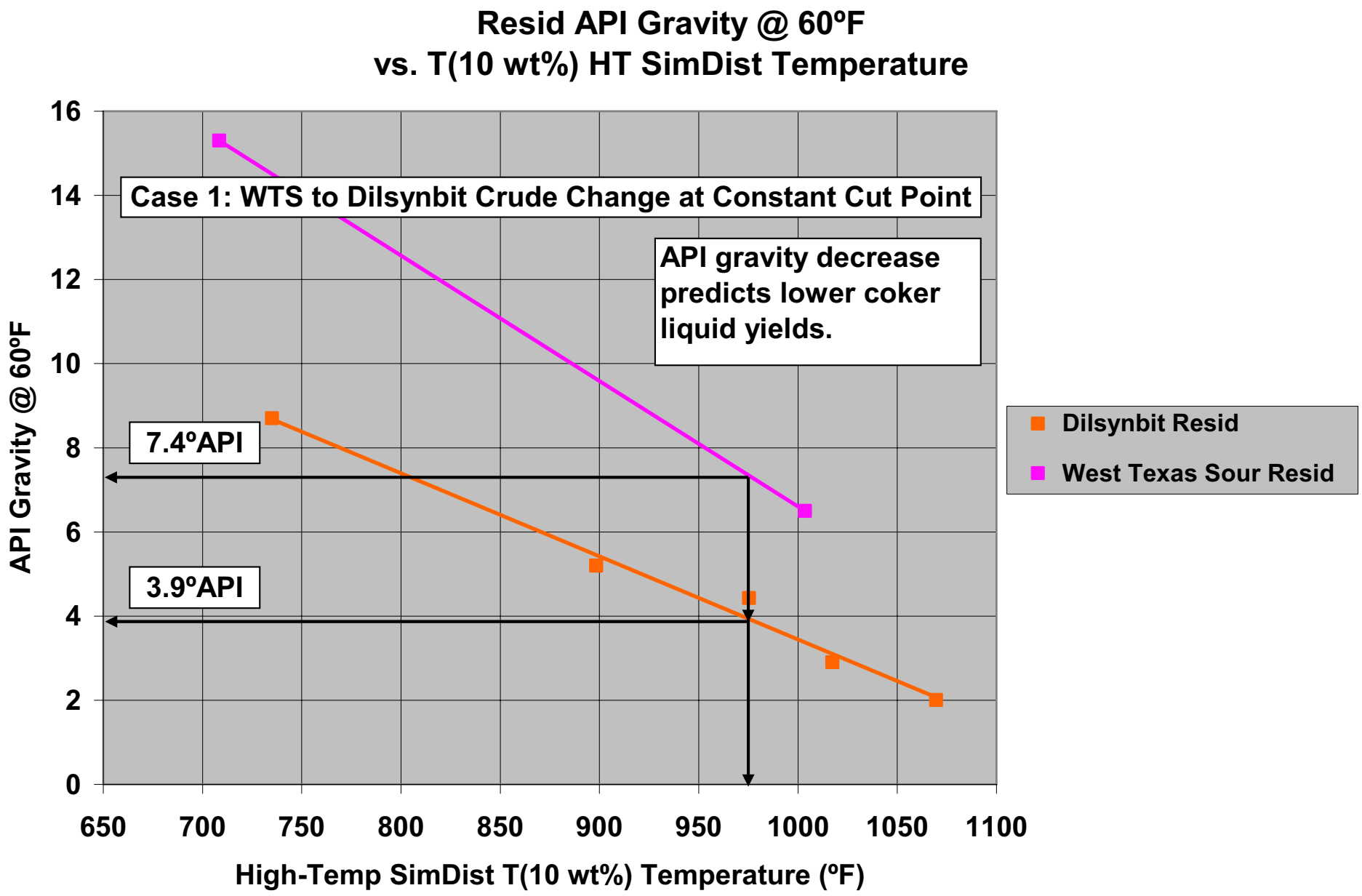
- A refiner running West Texas Sour crude wants to convert to Canadian dilsynbit. If the current vacuum tower bottoms cut point, represented by a HT SimDist T(10%) temperature of 975ºF, is maintained, what changes might the refiner expect in resid properties?

Resid Modified Viscosity @ 250ºF vs. T(10 wt%) HT SimDist Temperature



Modified Viscosity

- 0.1 = 17 cSt
- 0.2 = 38 cSt
- 0.3 = 98 cSt
- 0.4 = 324 cSt
- 0.5 = 1,452 cSt
- 0.6 = 9,573 cSt



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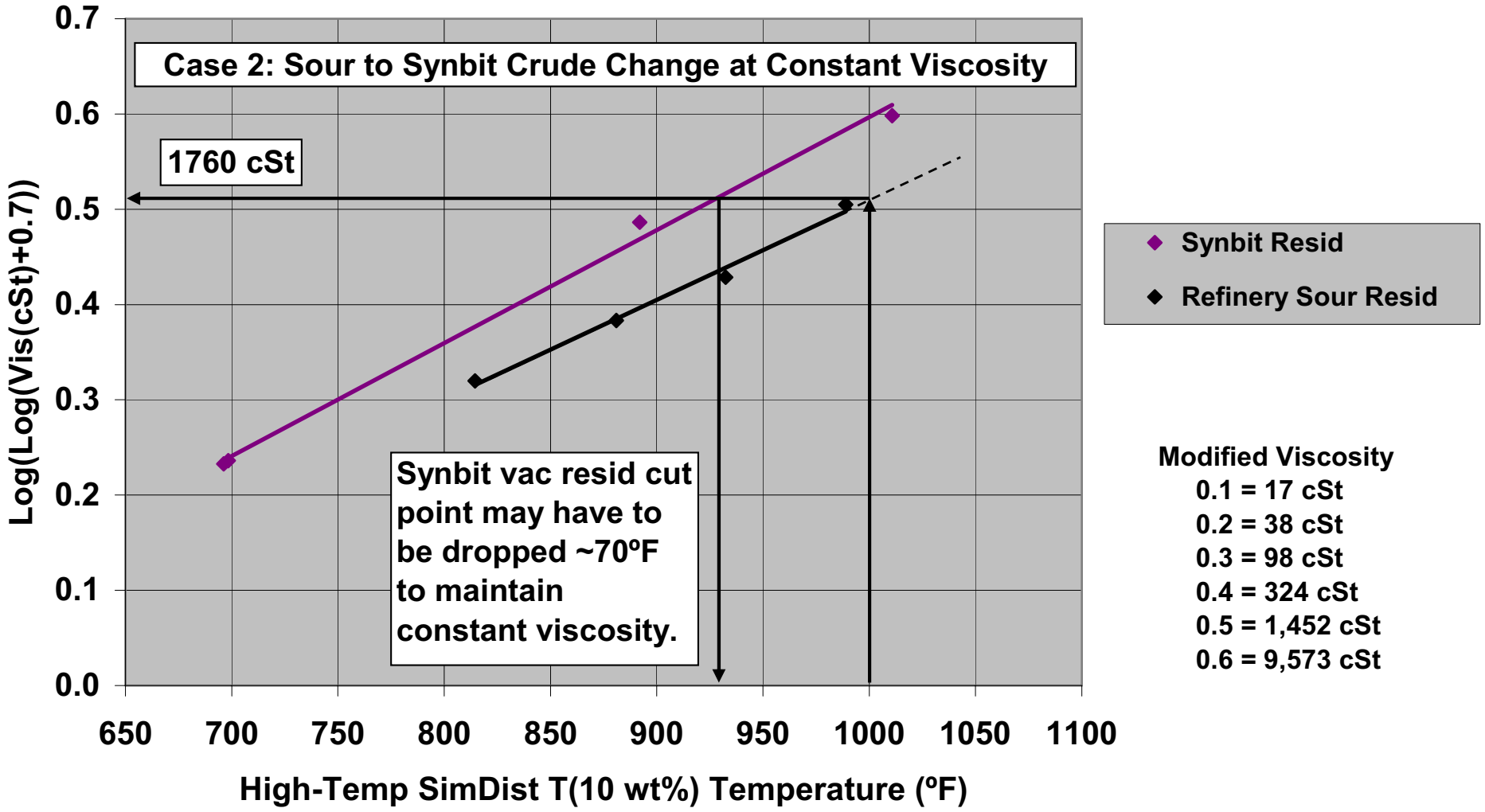
"What If" Scenario #2

- A refiner running a conventional sour crude slate wants to replace it with Canadian synbit. If the current vacuum tower bottoms cut point is represented by a HT SimDist T(10%) temperature of 1000ºF, how much might the vacuum tower cut point temperature have to be dropped to maintain a constant viscosity at 250ºF for asphalt sales?

Resid Modified Viscosity @ 250ºF vs. T(10 wt%) HT SimDist Temperature



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Conclusions

- Data from crude oil assays, supplemented with high-temperature SimDist data, can be used to predict key resid properties
- Assay-to-assay differences in reported resid properties can be explained by cut point temperature variations
- The impact of crude changes on resid gravity and viscosity can be modeled so that the refiner can
  - Revamp transfer systems to deal with changes in density and viscosity
  - Predict changes in coker yields
  - Change vac tower cut points to hit a target viscosity