- Viscosities of vapors:
  R-113: $\mu_g = 0.009446 + 0.000011713\ T$

Temperature, °F	Viscosity, cP
100	0.0106
130	0.011
160	0.0113
200	0.0118
240	0.01225

  Water: 0.012 cP (average)
  Noncondensable gases: 0.02 cP (average)
- Surface tensions:
  R-113: 30 dyn/cm
  Water: 65 dyn/cm
- Molecular weight:
  R-113: 187.4
  Noncondensable gases: 28.05
  Water: 18.02
- Critical properties of R-113:
  Critical temperature: 877.5°R
  Critical pressure: 494.72 psia
- Ideal gas specific heat ratio:
  R-113 vapor: 1.078
- Compressibility factor, *Z*:
  R-113: 0.89 (average over discharge flow conditions)
- Enthalpy (over the range of expected temperature for quench pool design.)
  R-113 vapor: $H_g = 0.1493\ T + 78.134$
  R-113 liquid: $H_f = 0.2374\ T + 6.1123$
  Water vapor: $H_g = 0.4233\ T + 1062.6$
  Water liquid: $H_f = 0.9989\ T - 31.884$
  where *H* is enthalpy, Btu/lbm; and subscripts g and f denote vapor and liquid, respectively.
- Latent Heats, Btu/lbm:
  R-113: $\lambda_1, = 72.022 - 0.0881\ T$
  water: $\lambda_q, = 1094.5 - 0.5756\ T$
- Specific heats:
  R-113 liquid: 0.0002 *T* + 0.2129 (approximately 0.2374 Btu/(lbm·°F) average over the range of quench pool operation.)
  Water: 0.9989 Btu/(lbm·°F) (average over the range of quench pool operation.)
  Noncondensable gas: 0.24 Btu/(lbm·°F)

Churchill, S. W. (1977). "Friction-Factor Equation Spans All Fluid-Flow Regimes." *Chemical Engineering,* 84 (November 7), 91-92.

Churchill, S. W., and Usagi, R. (1972). "A General Expression for the Correlation of Rates of Transfer and 0ther Phenomena." *AIChE Journal,* 18(6), 1121-1128.

Clayton, W. E., and Griffin, M. L. (1994). "Catastrophic Failure of a Liquid Carbon Dioxide Storage Vessel." *Process Safety Progress,* 13(4), 202-209.

Clift, R. (1978). *Bubbles, Drops, and Particles.* Academic Press, New York.

Coats, S. G. (1996). Personal Communication to CCPS Emergency Relief Effluent Subcommittee, Sept. 23.

Coats, S. G., Gardner, R. J., Whitcraft, W. K., and Tilley, B. J. (1995). "Source Modeling and Dispersion Modeling of Two-Phase Releases of Flammable Materials from Emergency Relief Systems." *Proceedings of the International Conference and Workshop on Modeling and Mitigating Consequences of Accidental Releases of Hazardous Materials,* New Orleans, September 26-29. AIChE/CCPS, New York, pp.693-720.

Coggins, P. E., and Furlong, G. C. (1972). "Flare System Operation at Sun Oil Company. *" Proceedings of API Division of Refining,* May 8-11. American Petroleum Institute, Washington, DC, pp. 907-918.

Coker, A. K. (1992). "Size Relief Valves Sensibly." *Chem. Eng. Progress,* 88(8), 20-27.

Coker, A. K. (1992a). "Size Relief Valves Sensibly—Part 2." *Chem. Eng. Progress,* 88(11), 94-102.

Cook, R. D., Fairweather, M., Hammonds, J., and Hughes, D. J. (1987). "Size and Radiative Characteristics of Natural Gas Flares. Part I—Field Scale Experiments." *Chem, Eng. Res. Des.,* 65, July.

Copigneaux, P. (1980). "Compare Codes for Relief Valve Calculations." *Hydrocarbon Processing,* August, 69-77.

Cox, 0. J., and Weirick, M. L. (1980). "Sizing Safety Valve Inlet Lines." *Chem. Eng. Progress,* 76(11), 51-54.

Crane (1988). "Flow of Fluids through Valves, Fittings, and Pipe." Technical Paper No. 410, Crane Company, Joliet IL.

Creed, M. L., and Fauske, H. K. (1990). "An Inexpensive Approach to the DIERS Procedure." *Chem. Eng. Progress,* 86(3), 45-49.

Crosby (1994). "Pressure Relief Valve Engineering Handbook." Technical Document No. TP-V300, Crosby Valve & Gage Company, Wrentham, MA.

Crowl, D. A., and Louvar, J. F. (1990). *Chemical Process Safety Fundamentals. Pren-* tice Hall, Englewood Cliffs, NJ.

Danckwerts (1970). *Gas-Liquid Reactions.* McGraw-Hill, New York.

Darby, R. (1996). Personal Communication (DIERS Users Group Project on Viscous Two-Phase Flow through Safety Relief Valves). August 5, 1996.

Darby, R, and Molavi, K. (1997). "Viscosity Correction Factor for Emergency Relief Valves." *Process Safety Progress,* 16(2), pp.80-82.