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THE TEMPERATURE DIFFERENCE IN NUCLEATE BOILING

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NOMENCLATURE

q, heat flux [Btu/h ft^2];
T_s, saturation temperature [°F];
T_w, surface temperature [°F];
ΔT, temperature difference, $T_w - T_s$ [degF].

FOR MANY nucleate pool boiling applications, the heat flux is specified and the temperature difference must be predicted. Frequently, test data on the system are not at hand and cannot be obtained. Because nucleate boiling depends so strongly on the unique interrelation between fluid properties and heater surface characteristics, generalized correlations may give estimates that are considerably in error, as noted in [1, 2]; further, the direction and probable magnitude of the error will be uncertain.

In this situation, it is helpful to compare temperature differences that have been observed for similar liquids boiling on a variety of surfaces. For example, Fig. 1 correlates experimental heat-flux–temperature-difference data [4–31] for pure, saturated organics (at atmospheric pressure) in the fully-developed nucleate pool boiling zone. Regression analysis showed this correlation to be highly significant: the variance ratio F is 100·028 (c.f. [3]). The scatter is little greater than that exhibited by generalized correlations. Figure 1 has the advantage of indicating the probable range of temperature difference to be expected.

Correlation points were obtained from separate plots of 94 data sets. Depending on the flux range of a set, up to four points were selected from a mean line at approximately equal-percentage flux increments, for a total of 276 points. The data include a wide variety of surfaces and organics; not all possible combinations are represented.

1. Liquids: Acetone, benzene, *i*-butanol, *n*-butanol, carbon disulfide, carbon tetrachloride, diethyl ether, diphenyl, ethanol, ethyl acetate, Freon-12®, Freon-113®, heptane, *n*-hexane, methanol, methyl chloroform, *n*-pentane, *i*-propanol, styrene, *m*-terphenyl, *o*-terphenyl, toluene.
2. Surfaces: Brass, chromium plate, copper, gold, Inconel, nickel, nickel plate, platinum, stainless steel, vitreous enamel, zinc (crystal).
3. Surface Treatment: None; No. 36, 60, 120 (lapped), 150, 200, and 320 grit polishes; mirror finish; acid and steel-wool cleaned; annealed and unannealed; fresh and aged.
4. Geometry: 0·005–1·5-in diameter cylinders (horizontal and vertical); $\frac{3}{4}$–3$\frac{3}{4}$-in diameter disks (vertical, horizontal facing up); $\frac{3}{4} \times \frac{3}{4}$-in and $\frac{3}{4} \times$ 4-in plates (vertical, horizontal facing up and facing down).

Since 95 per cent of any new data on similar systems is likely to fall within the probability limits, Fig. 1 is a useful guide for the prediction of the temperature difference in nucleate pool boiling for any organic on any surface at atmospheric pressure.

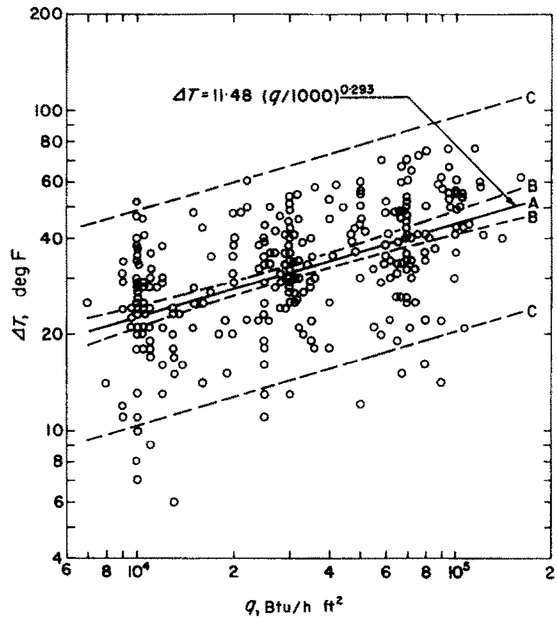

FIG. 1. Nucleate pool boiling of organic liquids at 1 atm: A, regression line; B, 95 per cent confidence limits on regression line; C, 95 per cent probability limits on ΔT predicted by regression.

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