BOILING CHANNEL CONDITIONS

FLUID FLOW

DIMENSIONLESS PARAMETERS

REYNOLD'S NUMBER : $R_e = \frac{VD}{\nu} = \frac{\rho V D}{\mu} \quad (\nu = \frac{\mu}{\rho})$

PRANDTL NUMBER : $P_r = \frac{C_p \mu}{k}$

NUSSELT NUMBER : $N_u = \frac{hD}{k}$

FLUID FRICTION IN CONDUIT

$$\Delta P = f \left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$ (IN CONSISTENT UNITS)

EQUIVALENT DIAMETER OF CHANNEL

$$D_e = 4 \frac{\text{CROSS SECTION}}{\text{WETTED PERIMETER}}$$

$$D_e = 4 \frac{\frac{1}{4}\pi D^2}{\pi D} = D$$ FOR CIRCULAR CHANNEL

CONVECTIVE HEAT TRANSFER INSIDE PIPE

$$N_u = 0.023 \, (R_e)^{0.8} (P_r)^{0.4}$$ FOR HEATING ($T_{PIPE} > T_{FLUID}$)

$$N_u = 0.023 \, (R_e)^{0.8} (P_r)^{0.33}$$

$$N_u = 0.023 \, (R_e)^{0.8} (P_r)^{0.3}$$ FOR COOLING ($T_{PIPE} < T_{FLUID}$)

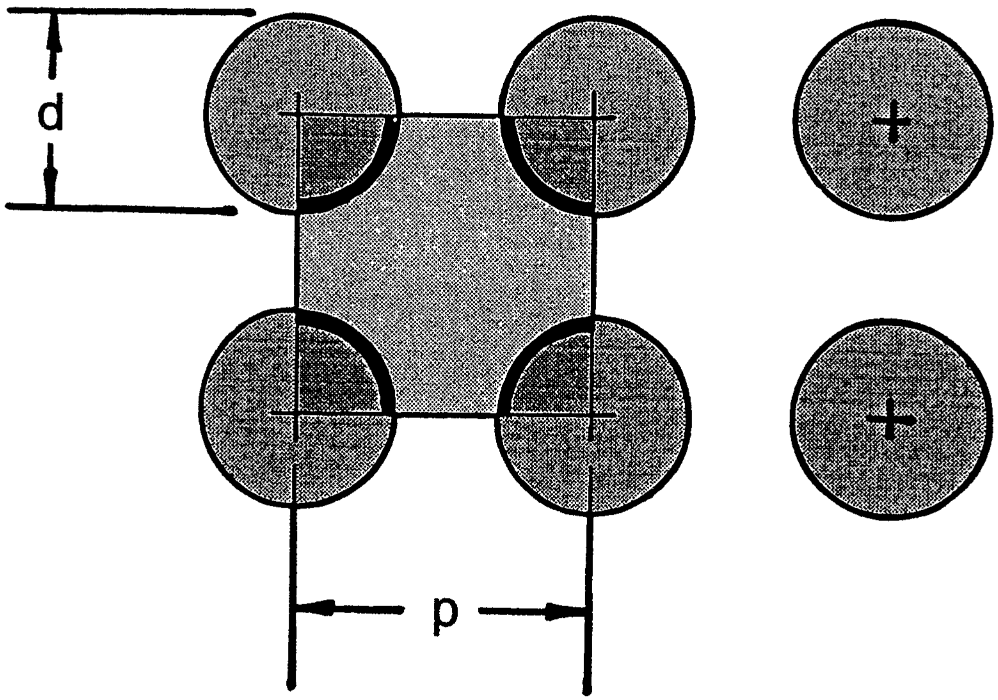
CONVECTIVE HEAT TRANSFER ACROSS TUBE BANK

$$N_u = F_a \, 0.287 \, (R_e)^{0.6} (P_r)^{0.33}$$

F_a = ARRANGEMENT FACTOR

ALTERNATIVE FLUID FRICTION FORMULA

$$\Delta P = 4f \left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$ (IN CONSISTENT UNITS)



Flow Area = $p^2 - (\pi d^2 / 4)$

Wetted Perimeter = πd

Figure 5 Definition of factors constituting equivalent diameter

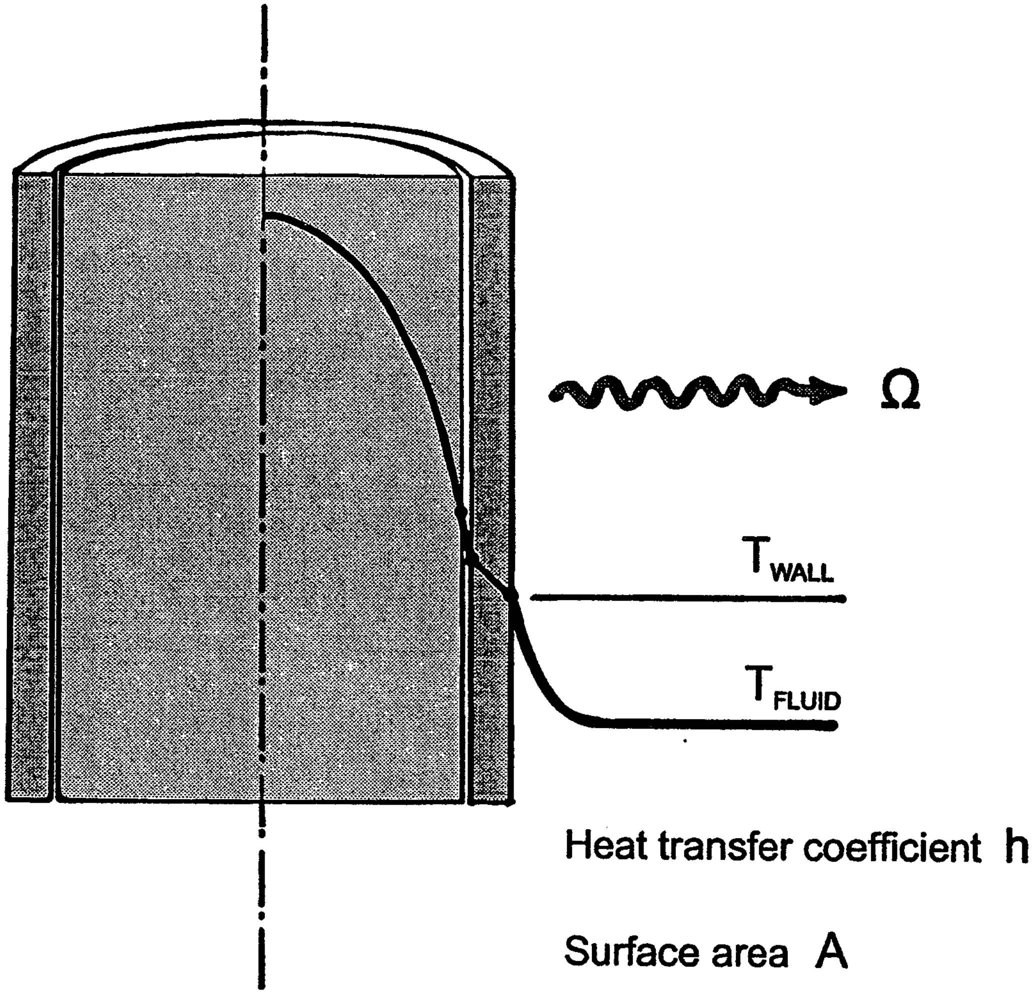


Figure 4 Heat convection from fuel rod surface

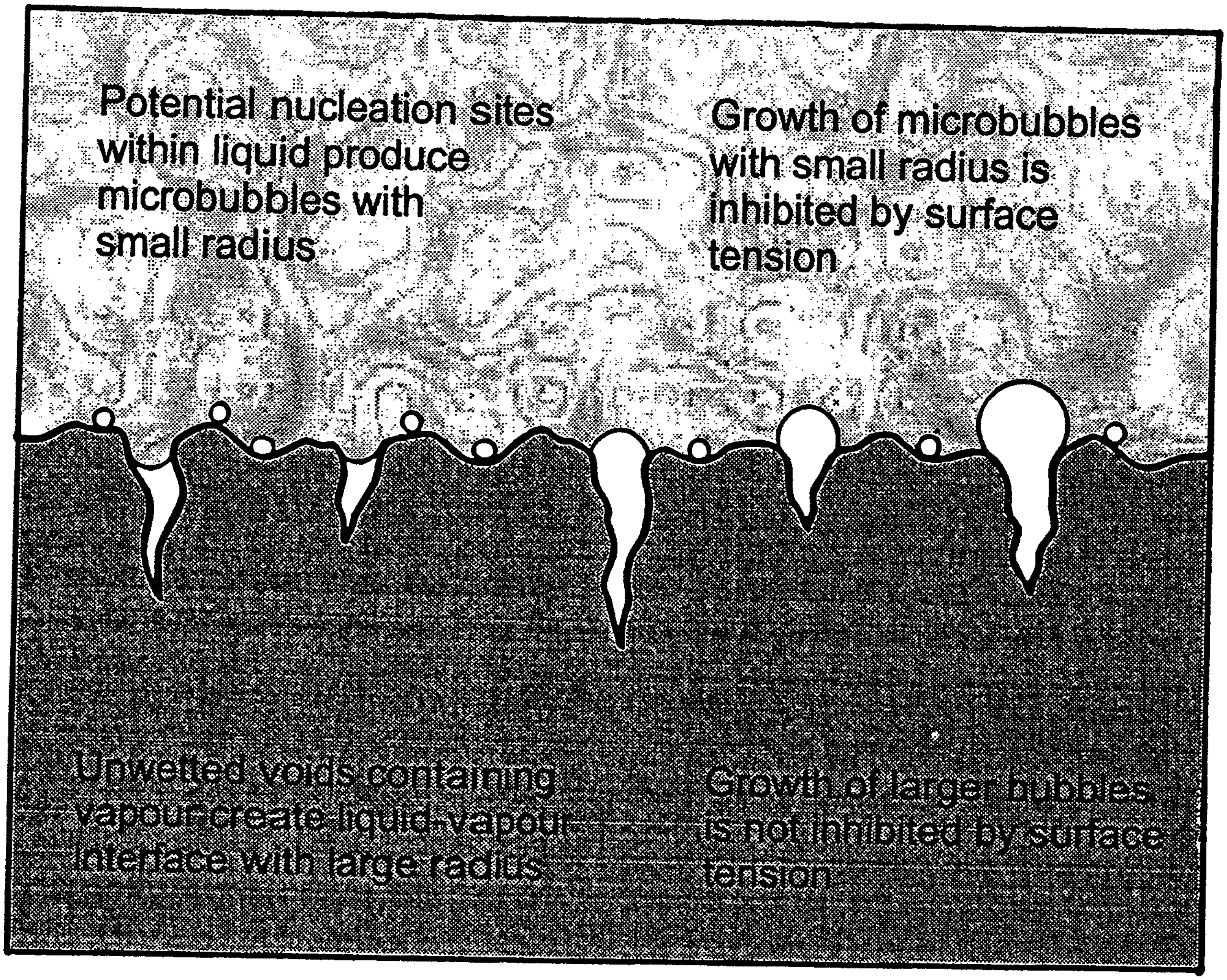
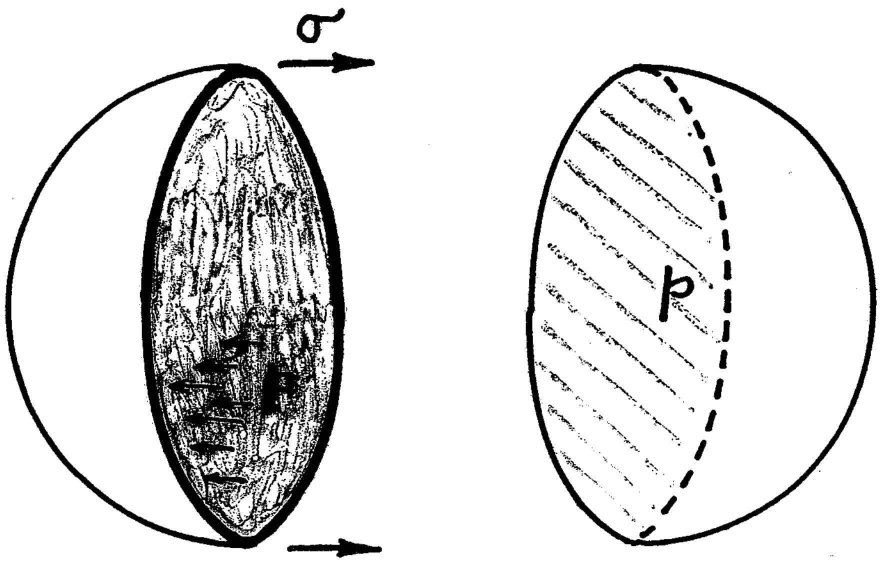


Figure 6 Vapour bubble formation during boiling

BUBBLE OR DROP



FORCE DUE TO SURFACE TENSION

$$F = 2\pi r \sigma$$

FORCE DUE TO INTERNAL PRESSURE

$$F = \pi r^2 p$$

EQUATING FORCES

$$2\pi r \sigma = \pi r^2 p$$

$$p = \frac{2\sigma}{r}$$

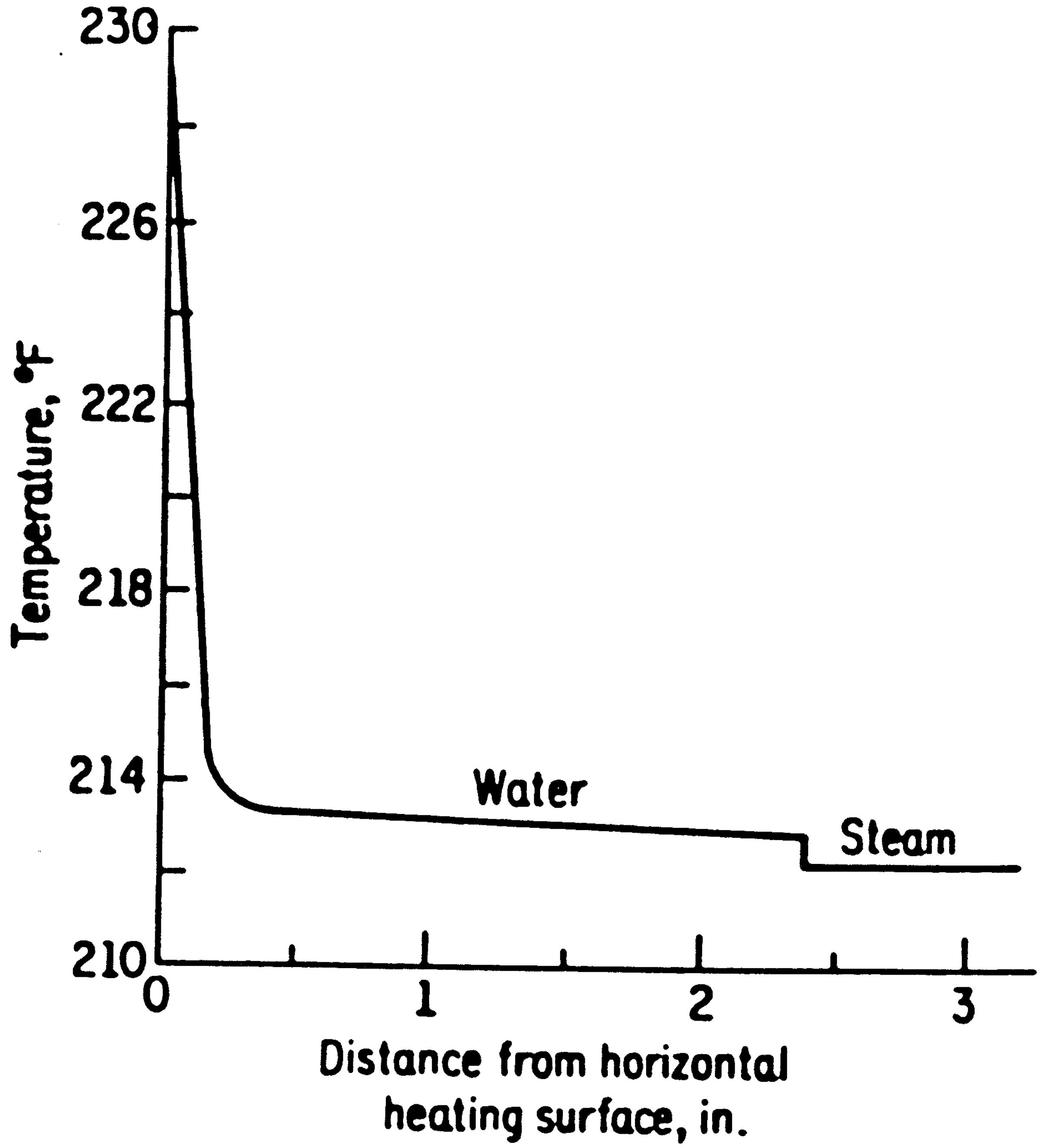
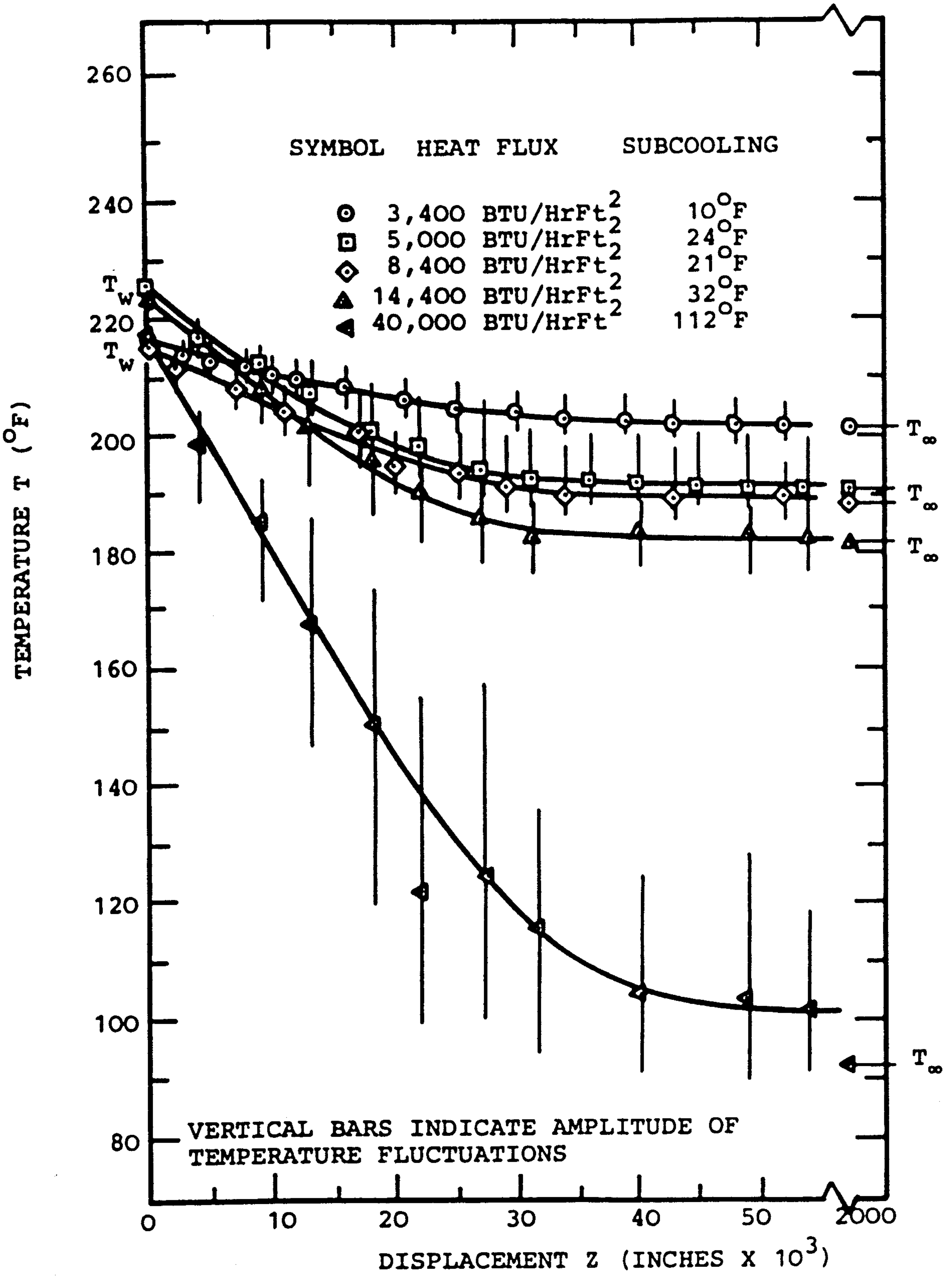


FIG. 11-5. Water temperature above heating surface at atmospheric pressure (Ref. 35).



FROM REF. (W 9)

FIG. 21: TEMPERATURE PROFILES AT INCIPIENT BOILING CONDITION

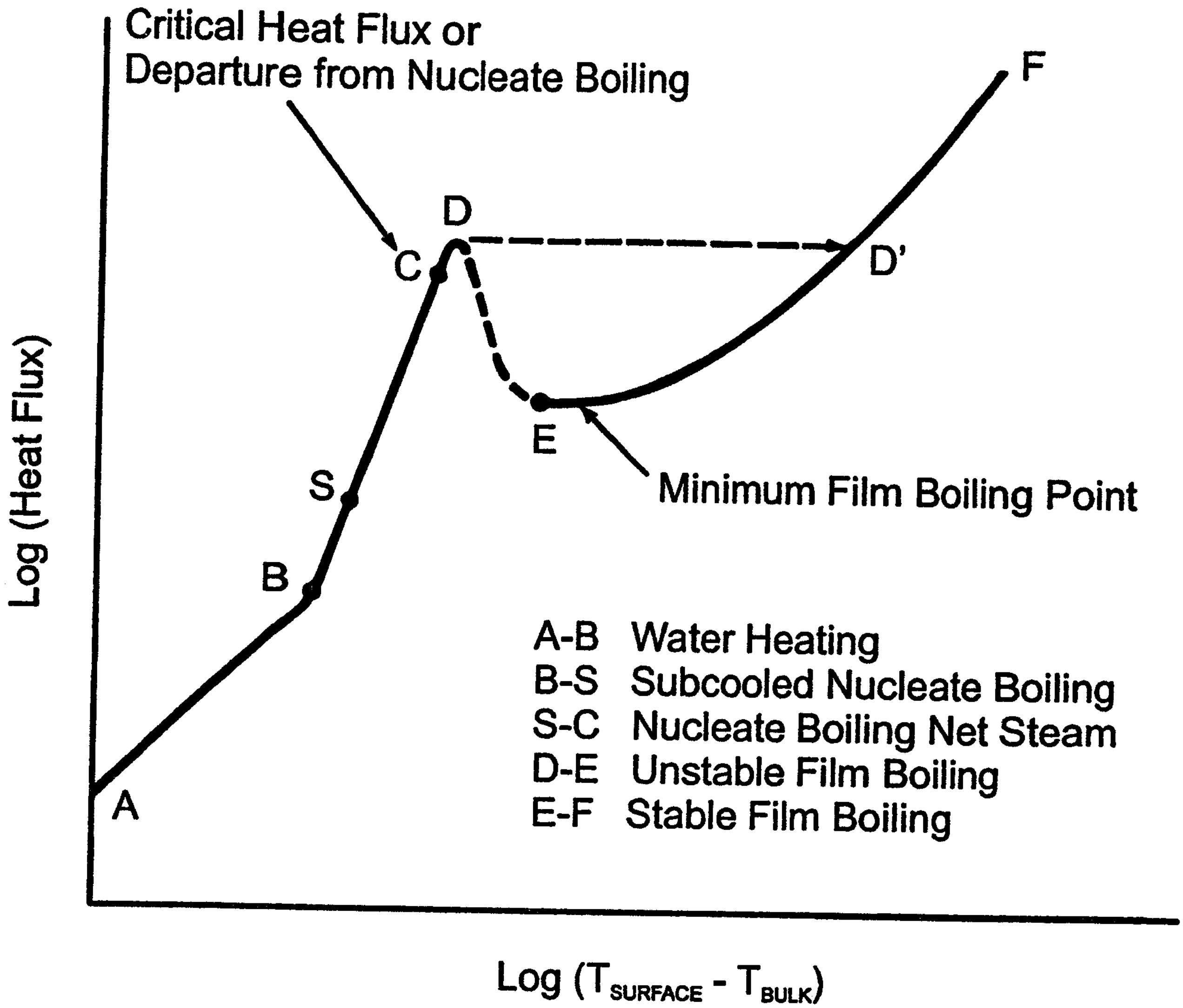


Figure 7 Pool boiling curve (courtesy of Babcock & Wilcox)

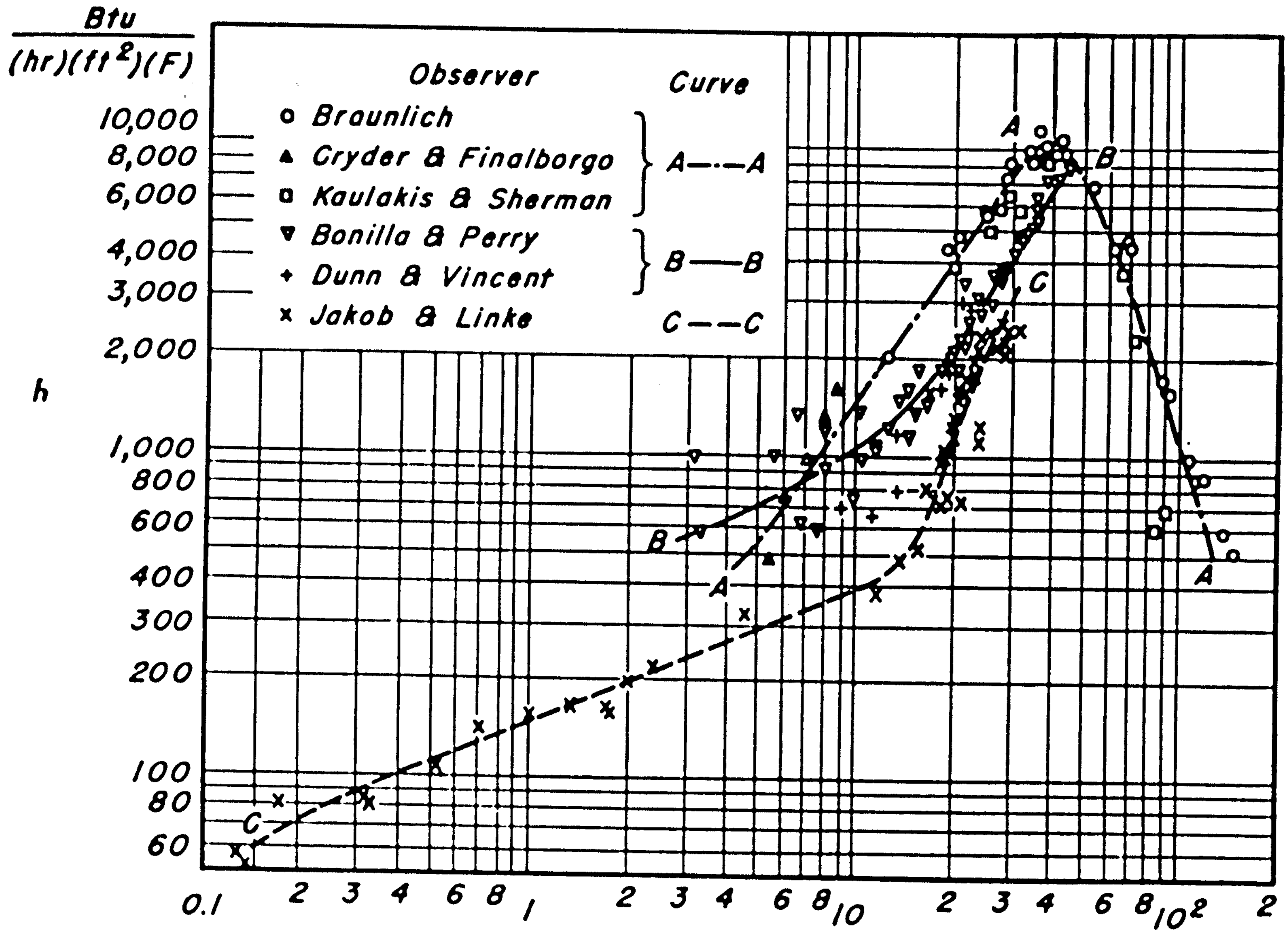


FIG. 12-9. Heat-transfer coefficients for water boiling on horizontal tubes (*A*) and horizontal plates (*B* and *C*) at 1 atm. (*From W. H. McAdams, "Heat Transmission," 2d ed., McGraw-Hill Book Company, Inc., New York,* 1942.)

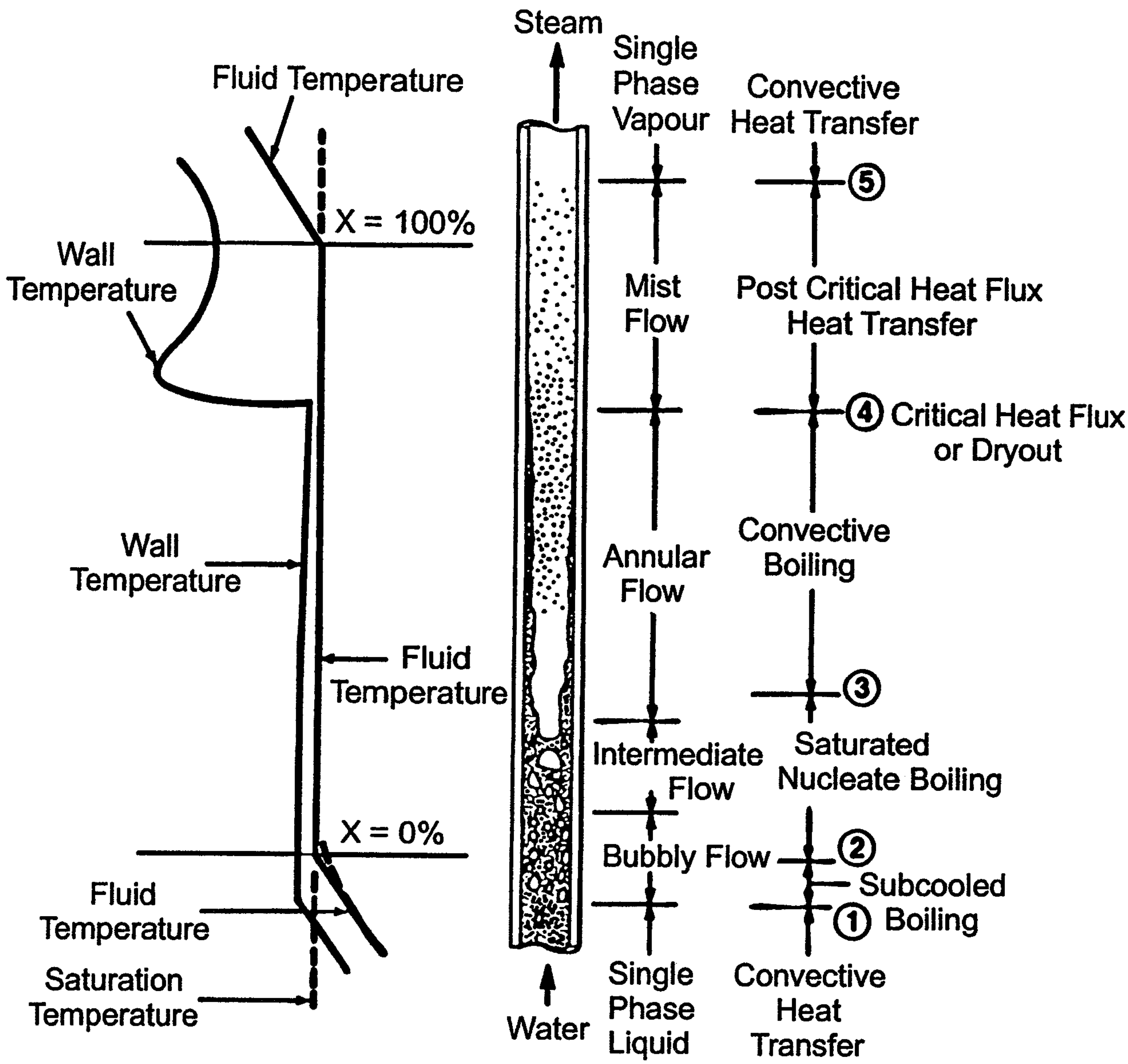


Figure 8 Flow boiling in vertical channel (Courtesy of Babcock & Wilcox)

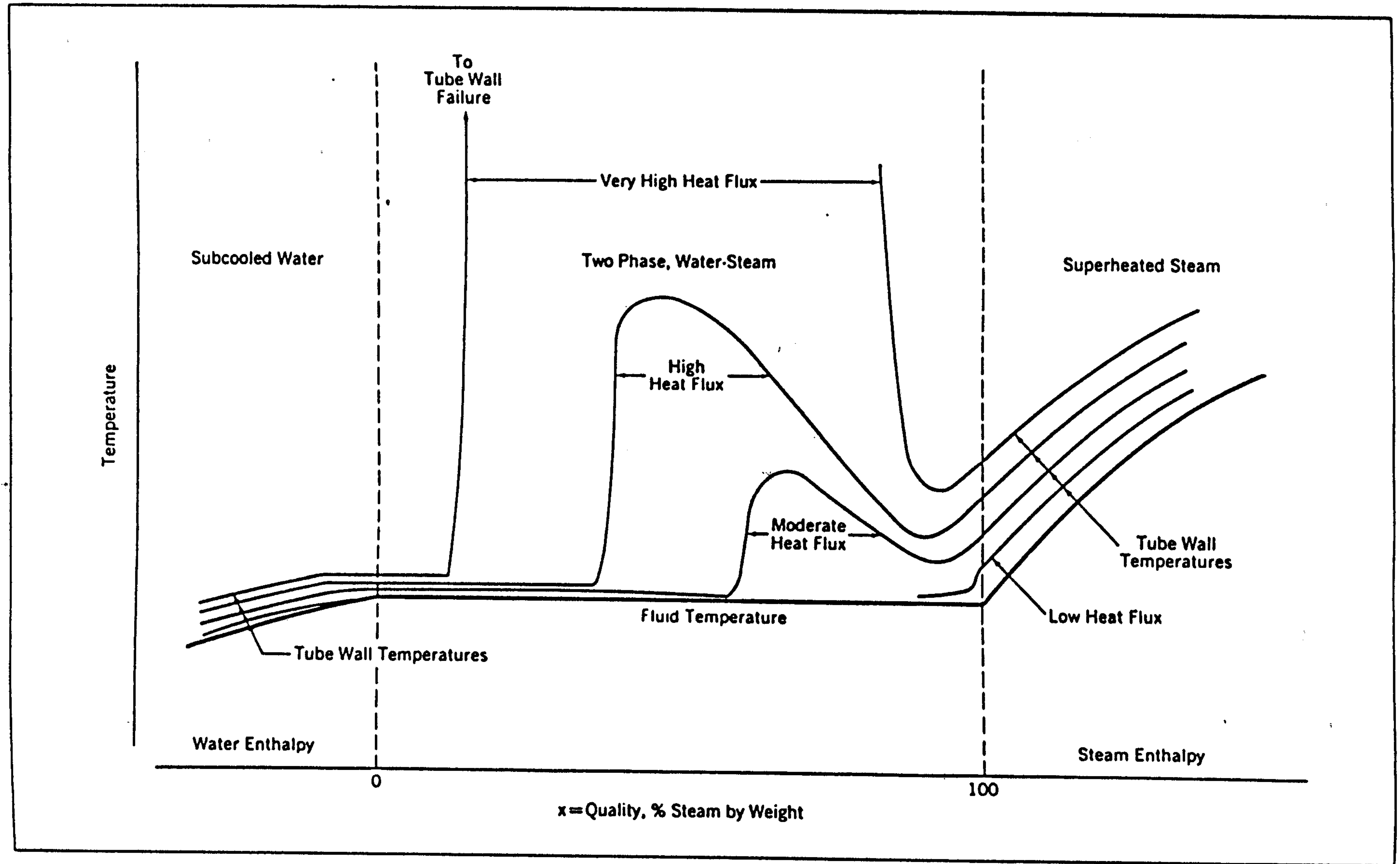


Fig. 2 Fluid and tube wall temperatures under conditions of water heating, nucleate boiling, film boiling and superheating steam.

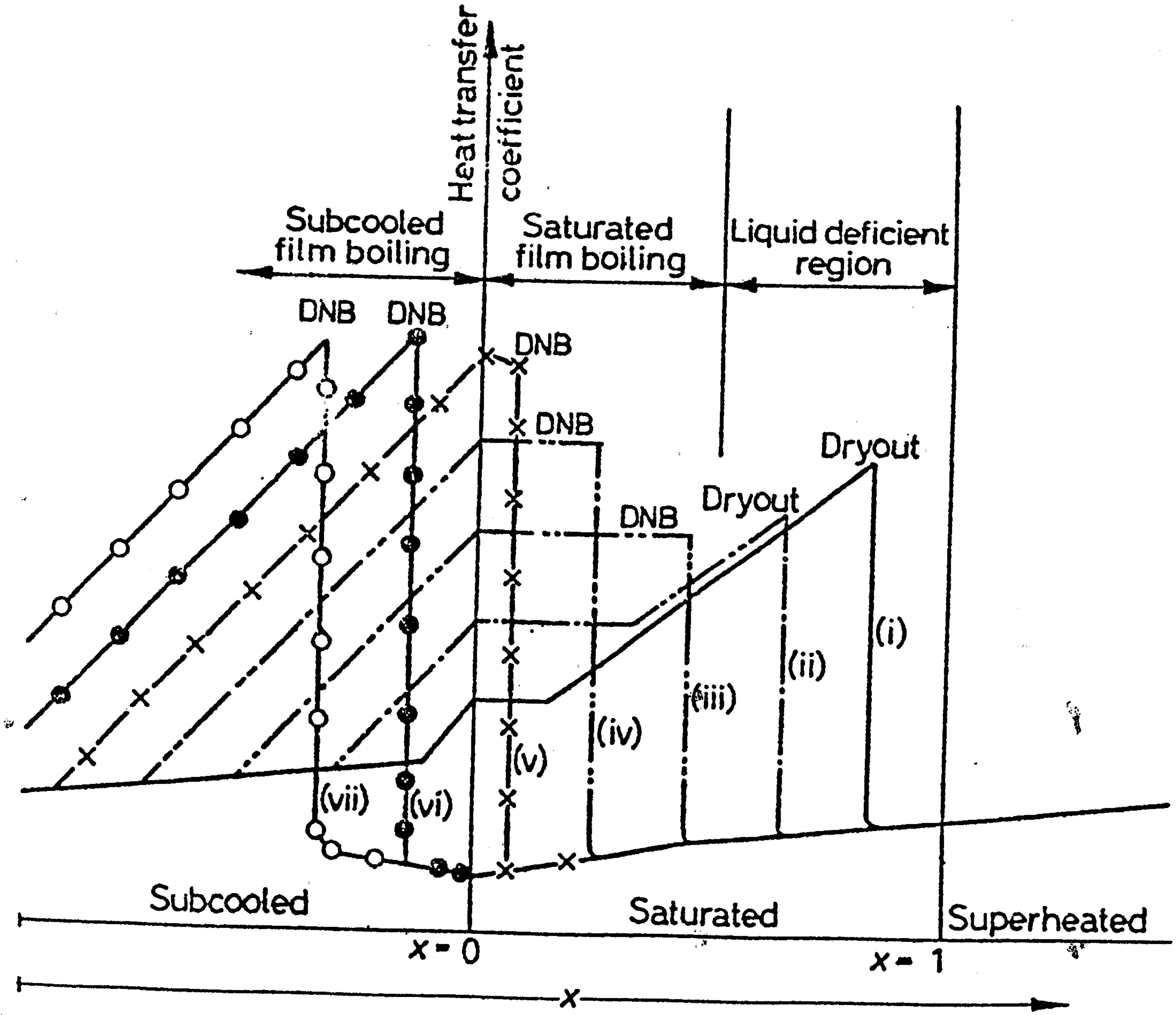


FIG. 19 Typical form of the variation of heat transfer coefficient with heat flux and quality. From Collier (1972).

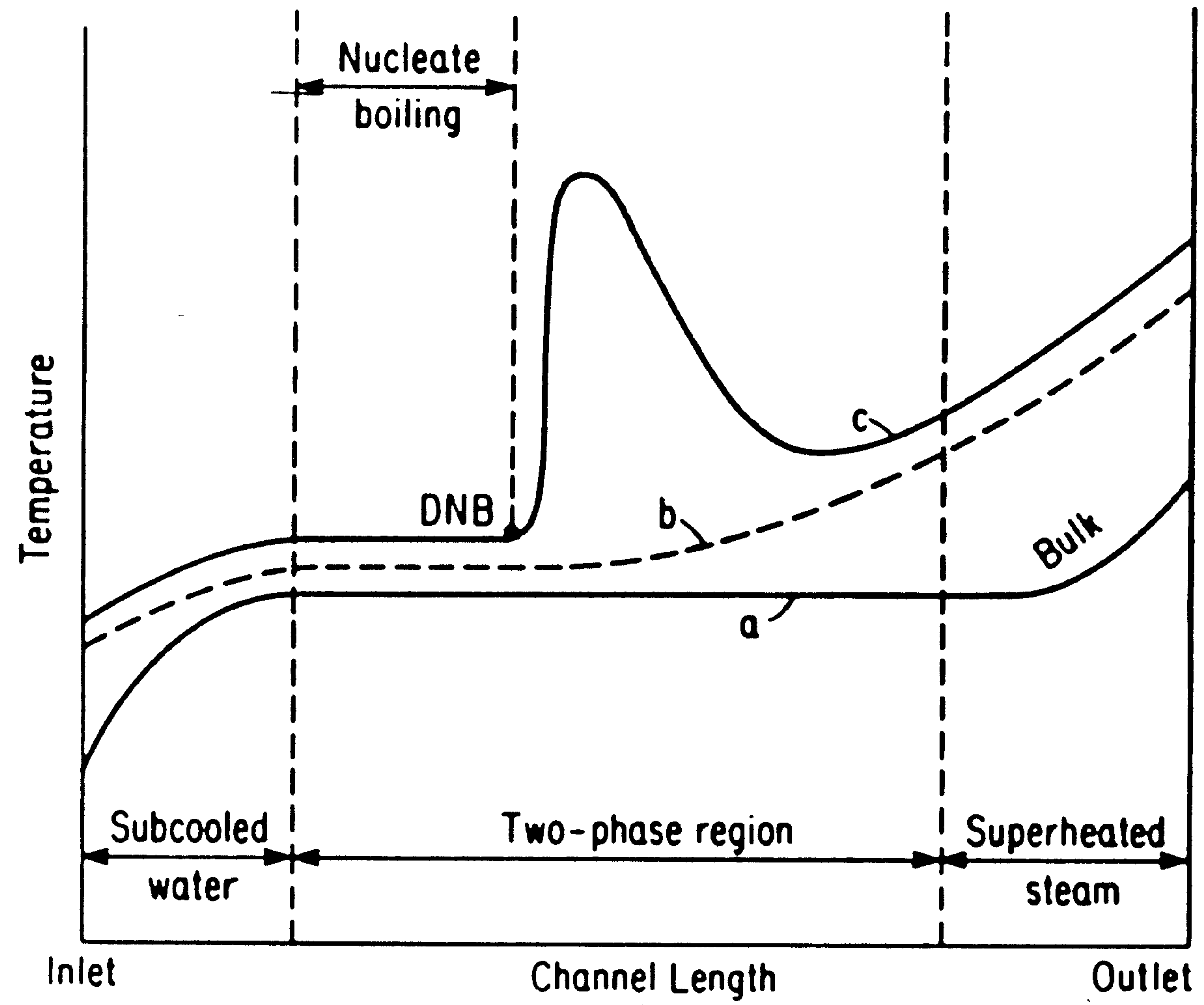


FIG 11-10. Flow boiling crisis (Ref. 88).

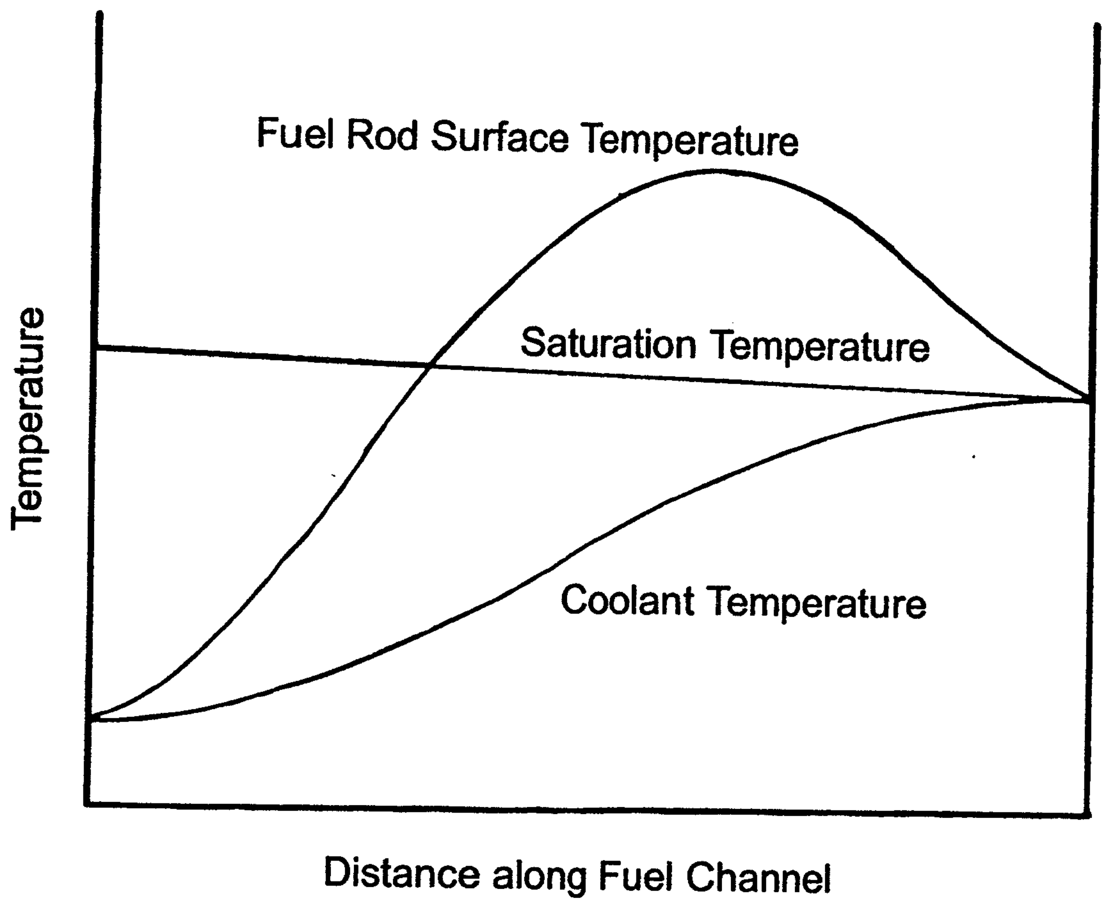
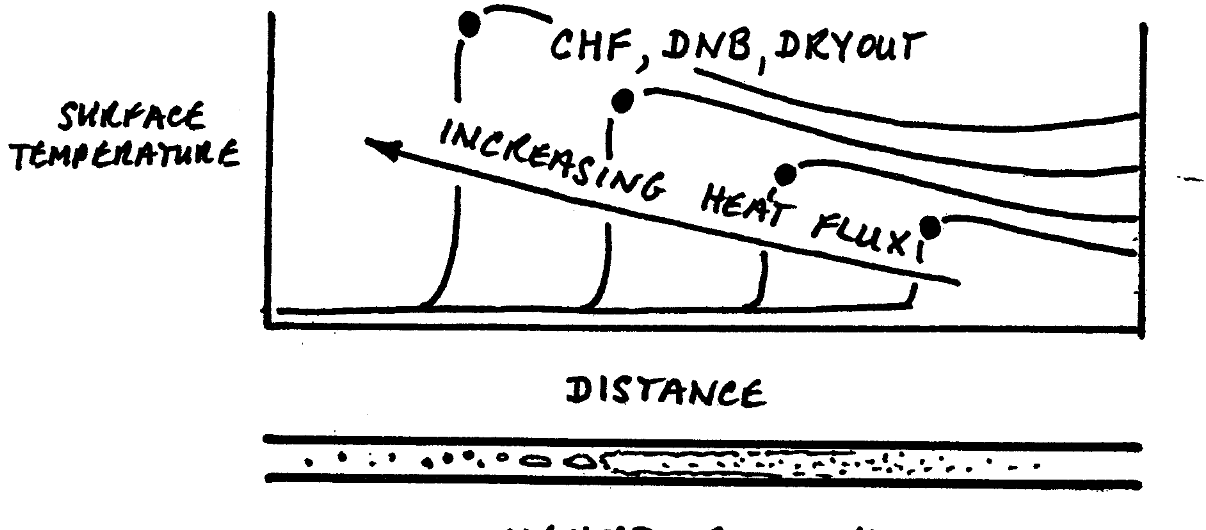


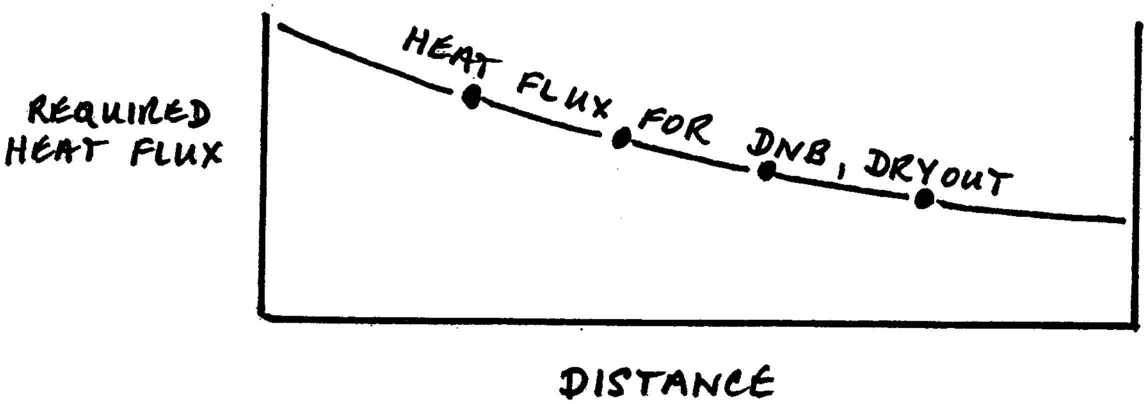
Figure 6 Temperature profiles along a fuel channel

CRITICAL HEAT FLUX

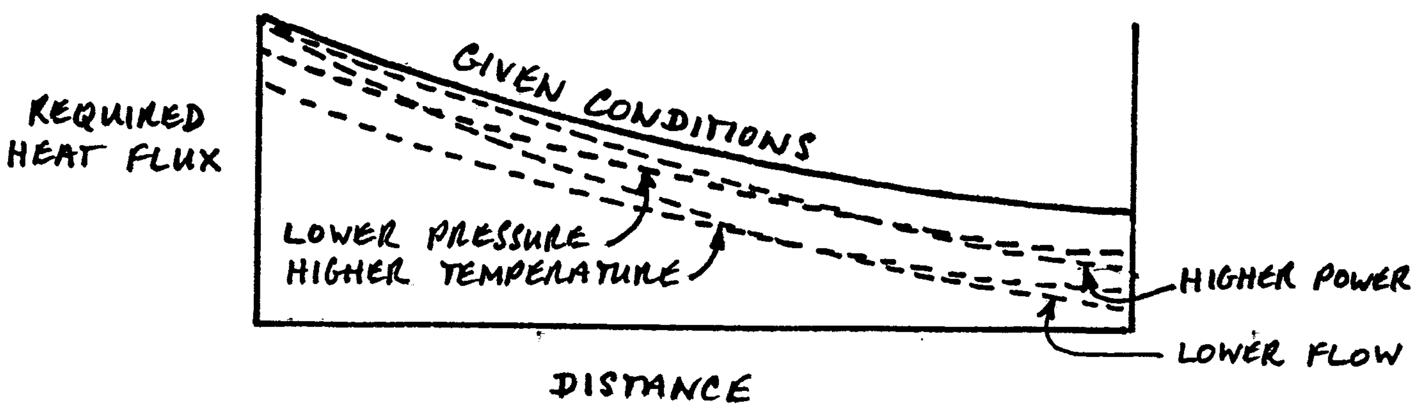
TEMPERATURE PROFILES FOR DIFFERENT HEAT FLUXES



CRITICAL HEAT FLUX VARIATION FOR FIXED CONDITIONS



VARIATION IN CRITICAL HEAT FLUX



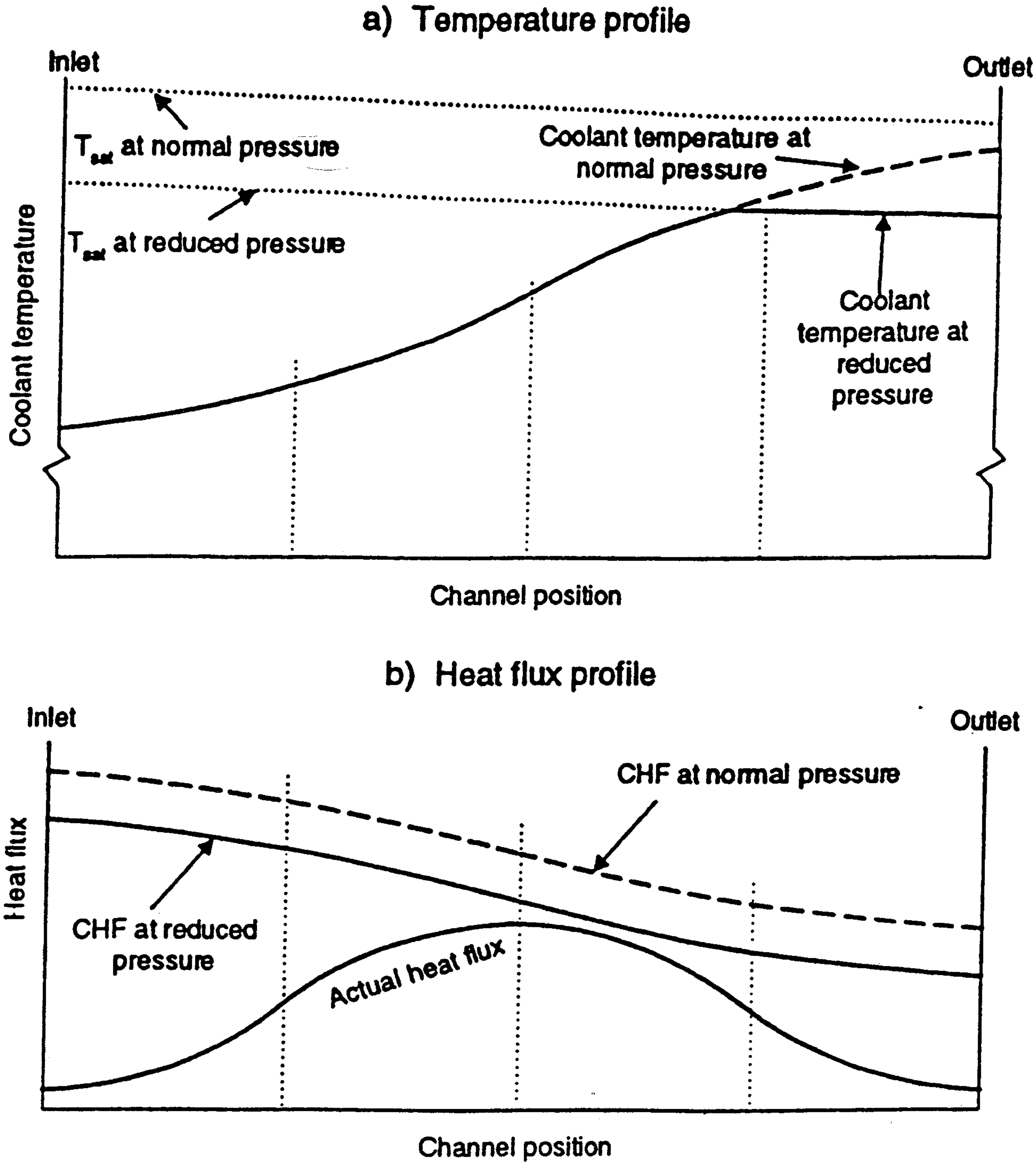


Figure 7.7: Effects of Low Coolant Pressure

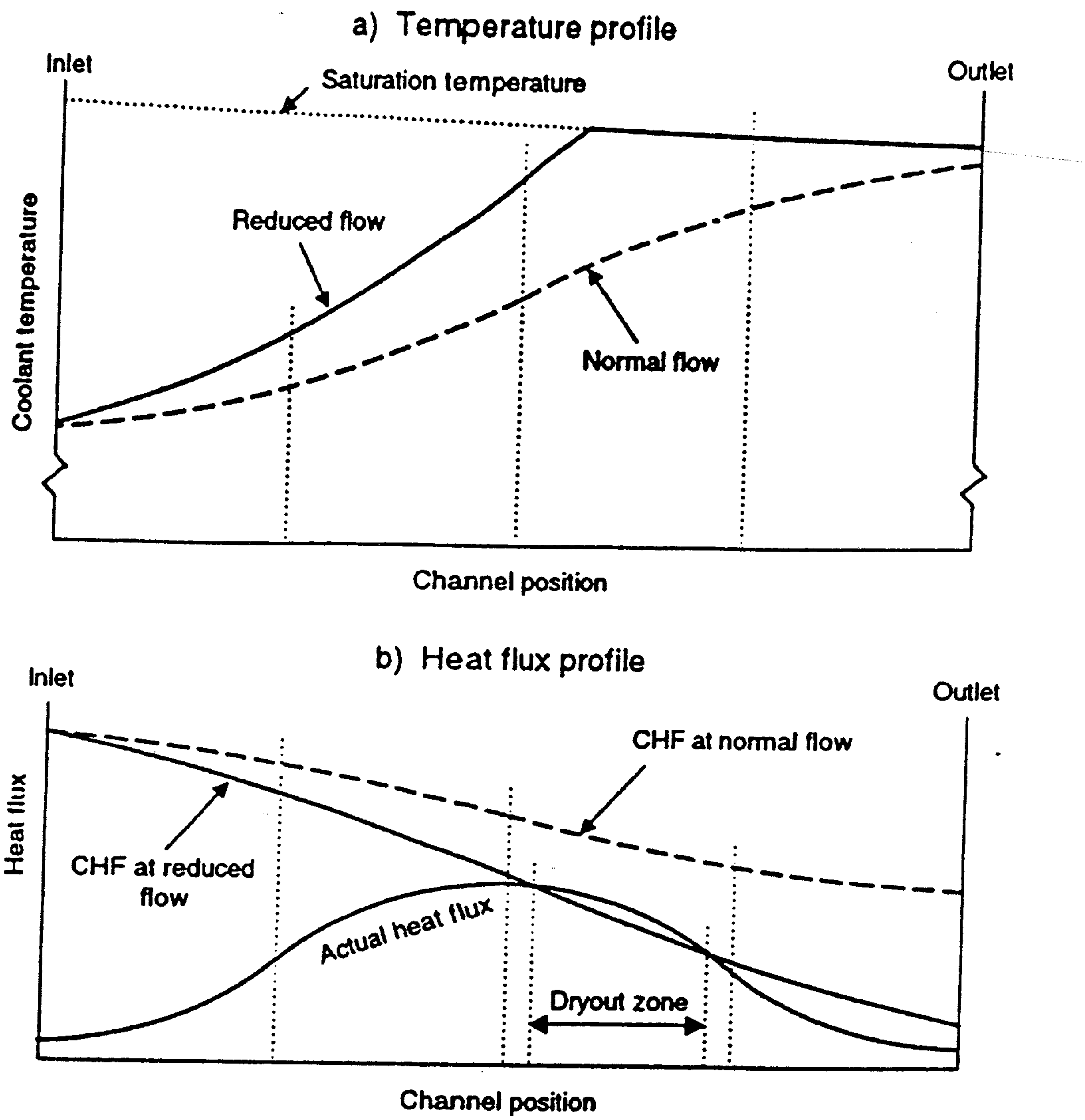


Figure 7. 8: Effects of Reduced Channel Flow

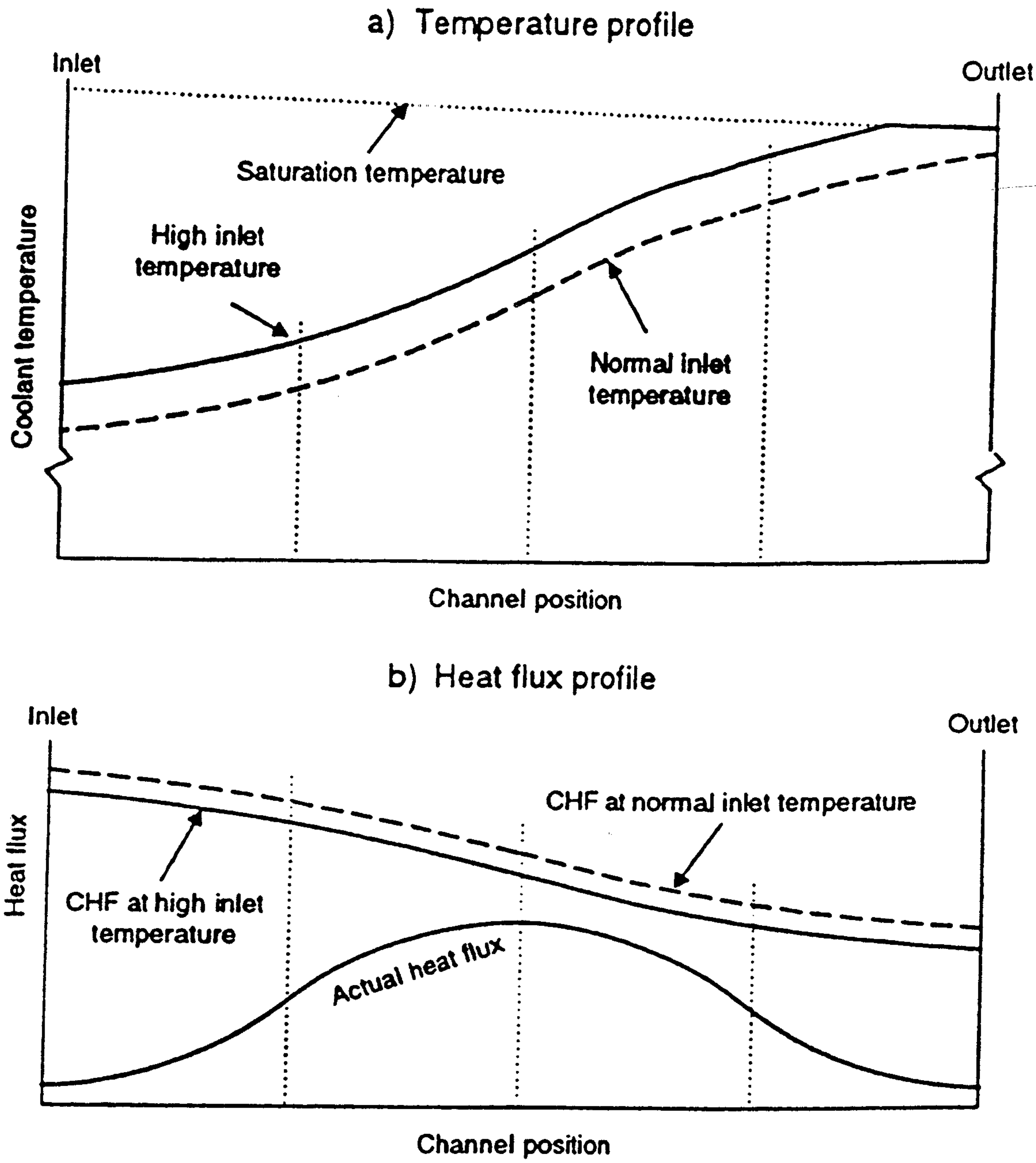


Figure 7. 9: Effects of Increased Channel Inlet Temperature

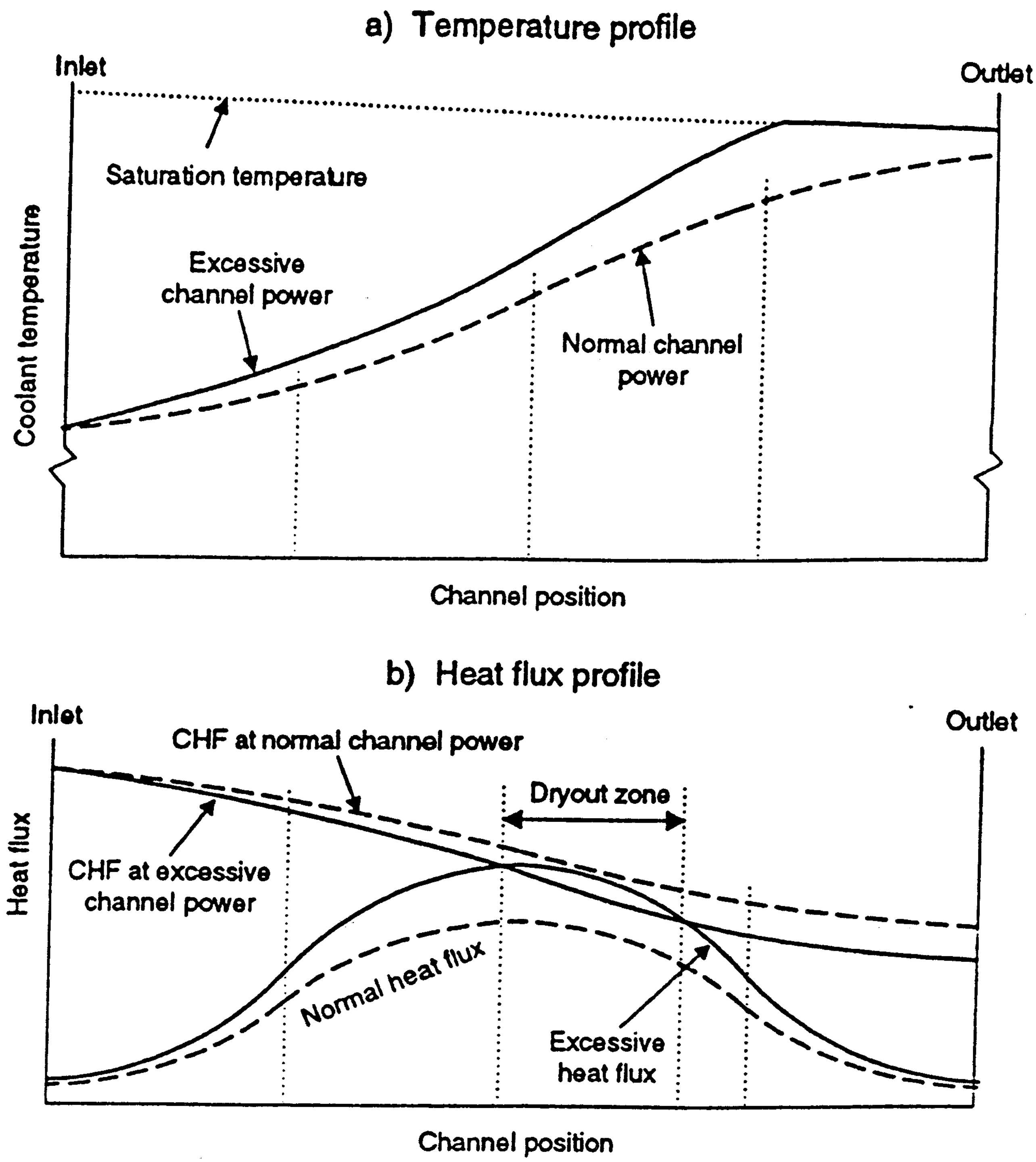


Figure 7.12: Effects of Excessive Channel Power