Power Distribution Limits

Westinghouse Technology
Systems Manual Section 2.2

Objectives

1 Define the following terms:

- Departure from nucleate boiling (DNB)
- Departure from nucleate boiling ratio (DNBR)
- Power density (linear heat generation rate)
- Heat flux hot channel factor (F_Q)
- Axial flux difference (AFD)
- Enthalpy rise hot channel factor ($F^N_{\Delta H}$)
- Quadrant power tilt ratio (QPTR)

Objectives (Continued)

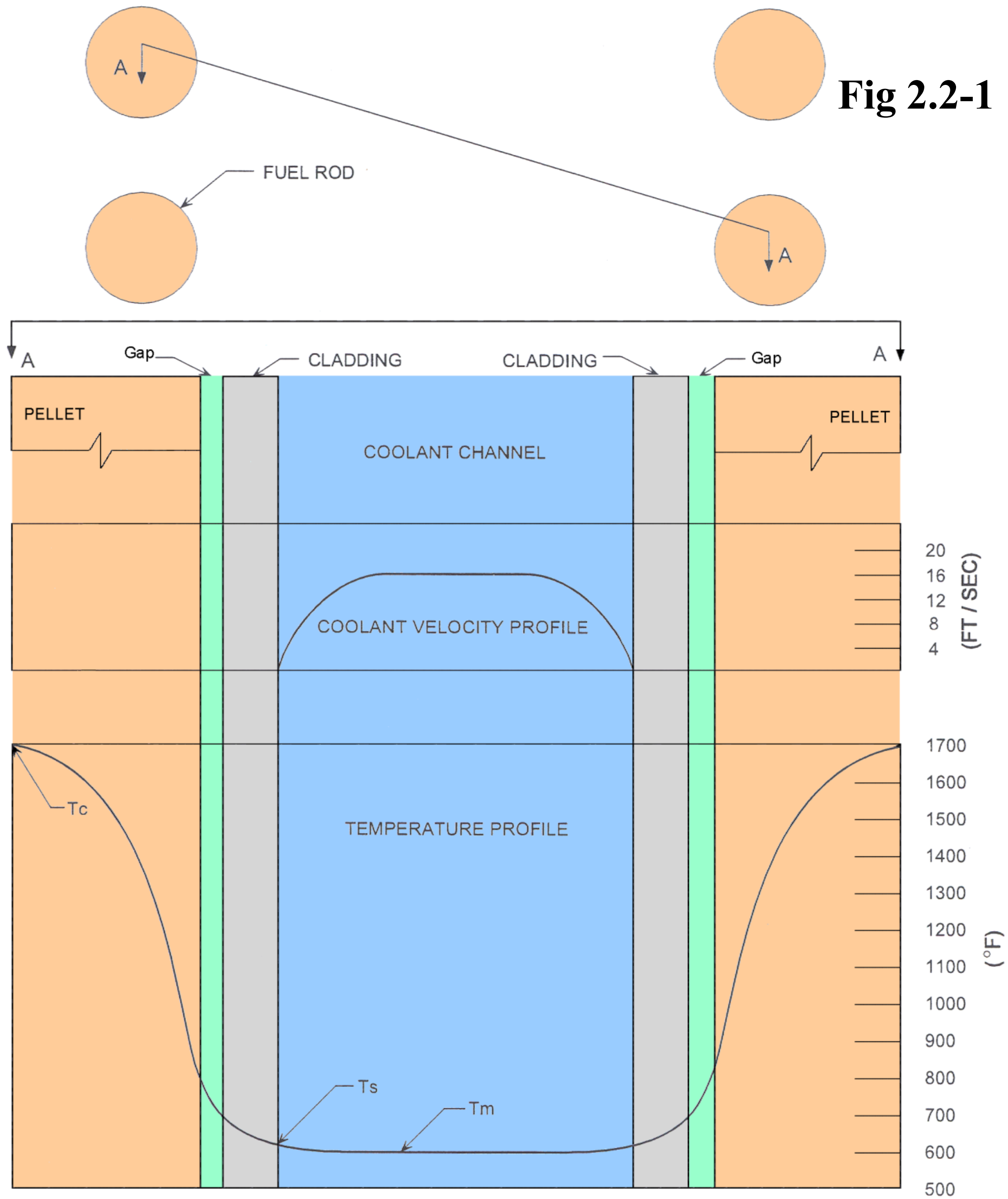
2 Explain why DNBR is required to be greater than a specific limit.

3 Explain why F_Q limit is varied as a function of core height.

4 Explain why surveillance intervals of 31 effective full power days are adequate to ensure that peaking factor limits are not exceeded.

5 Explain how AFD limits ensure F_Q is not exceeded.

Fig 2.2-1

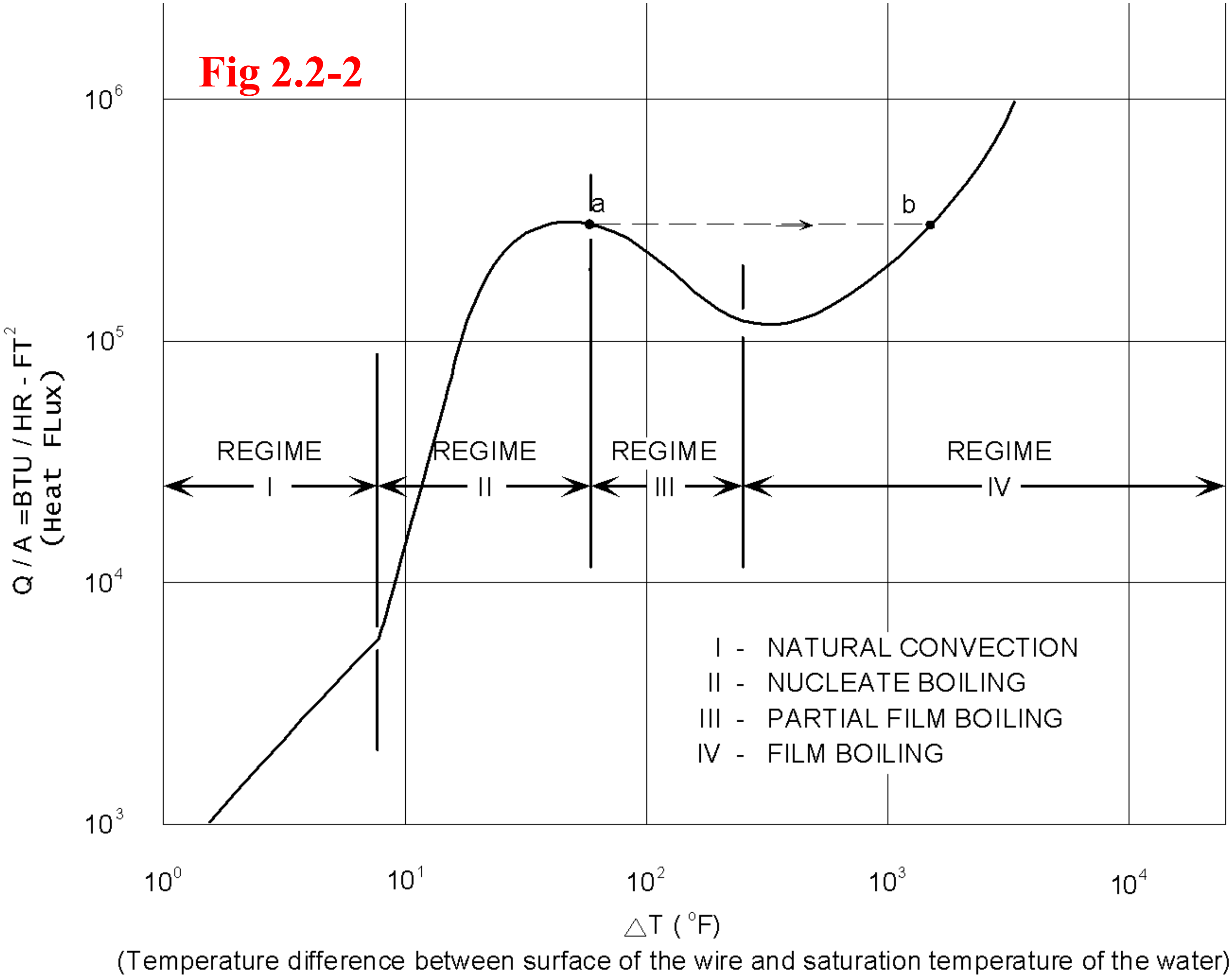


Tc - Pellet Centerline Temperature

Ts - Rod Surface Temperature

Tm - Moderator Temperature

Fig 2.2-2


10^6
10^5
10^4
10^3
Q / A =BTU / HR - FT^2
(Heat FLux)
a
b
REGIME I
REGIME II
REGIME III
REGIME IV
I - NATURAL CONVECTION
II - NUCLEATE BOILING
III - PARTIAL FILM BOILING
IV - FILM BOILING
10^0
10^1
10^2
10^3
10^4
△T (°F)
(Temperature difference between surface of the wire and saturation temperature of the water)

DNBR

$$DNBR = \frac{the\ heat\ \ flux\ required\ to\ reach\ DNB}{the\ actual\ heat\ \ flux}$$

Or,

$$DNBR = \frac{CHF}{AHF}$$

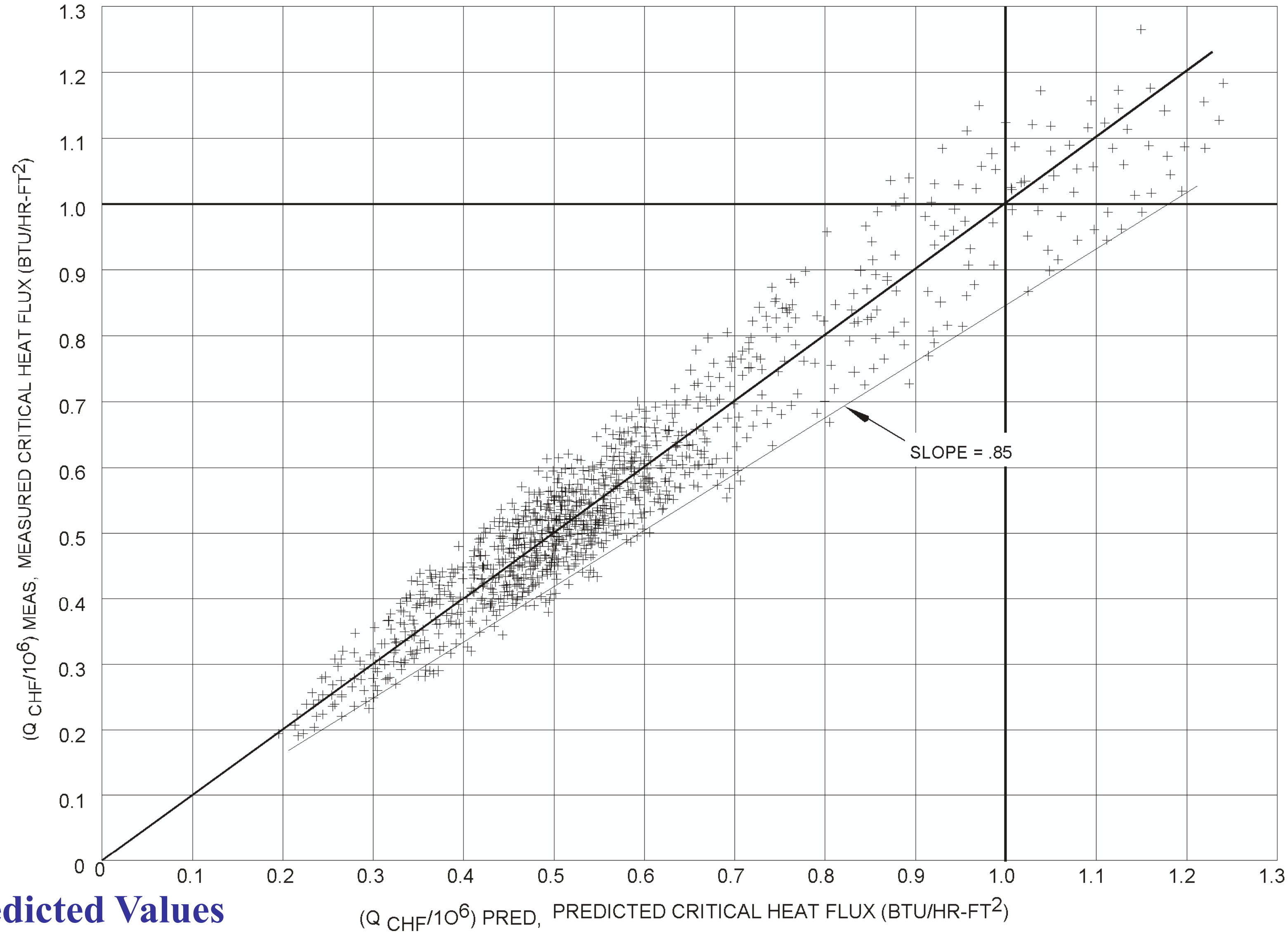


Figure 2.2-3 Measured versus Predicted Critical Heat Flux

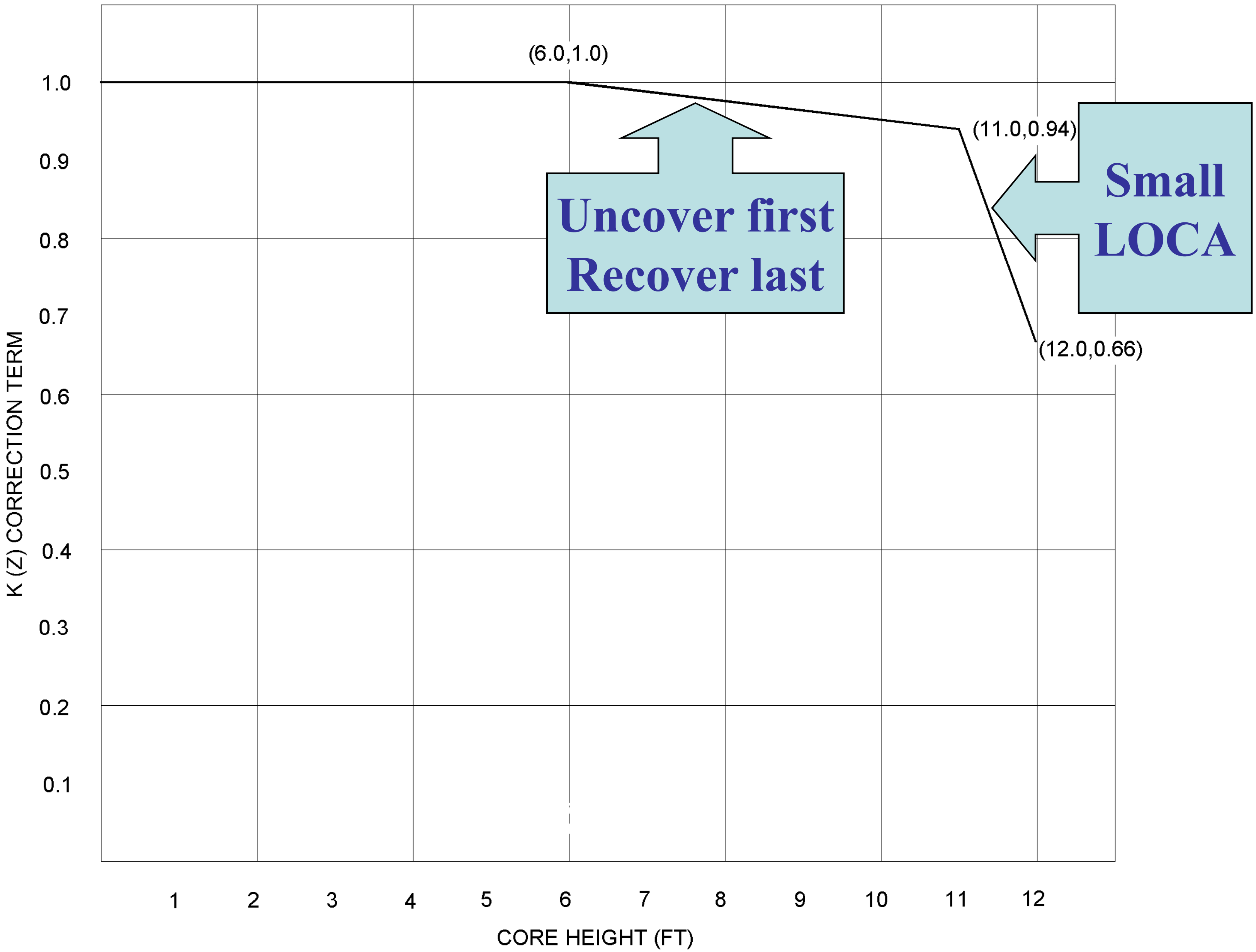
Predicted Values based on calc's

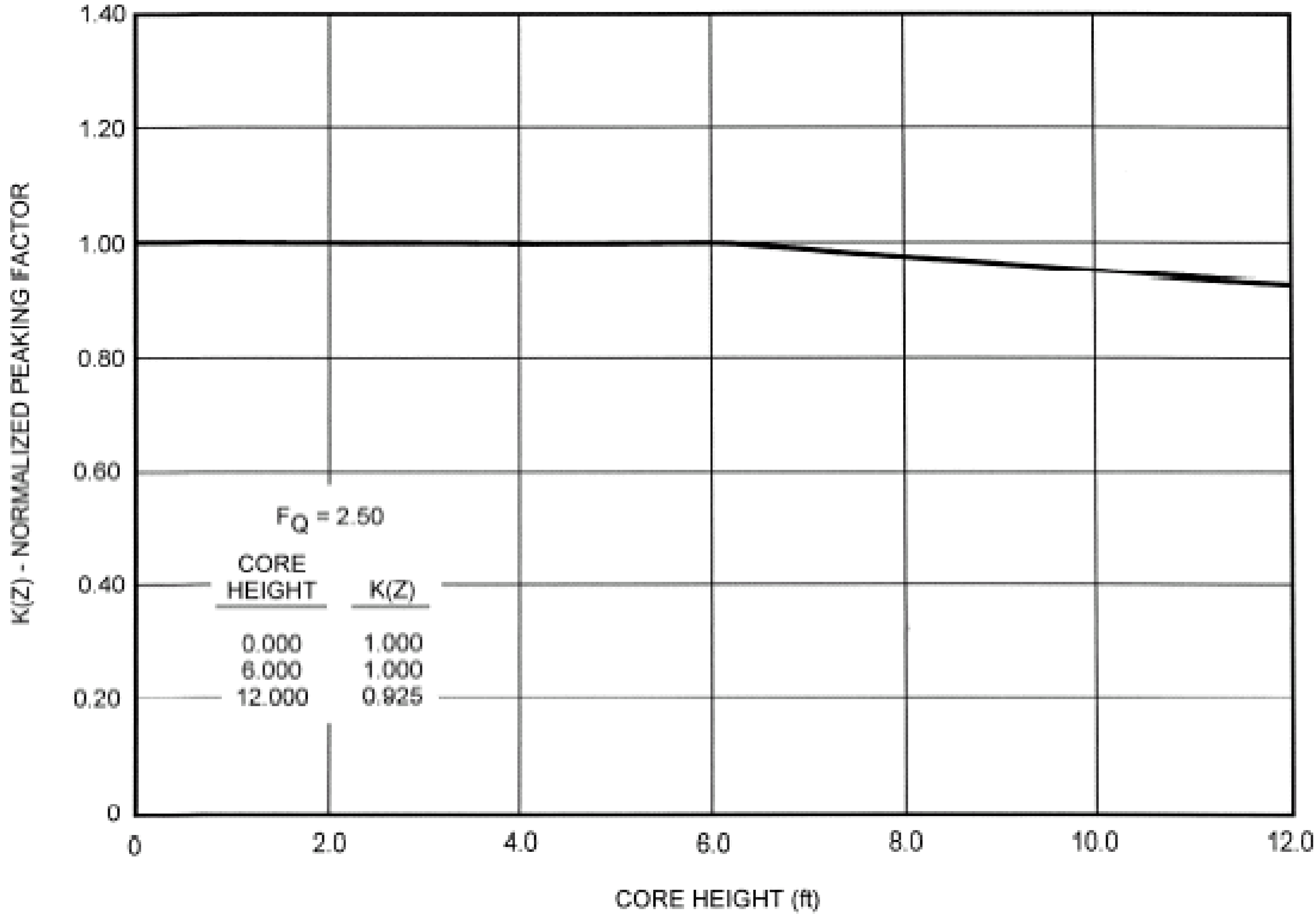
0199-3

Fig 2.2-3

Heat Flux Hot Channel Factor - F_Q

$$F_Q = \frac{Maximum\ \ (Peak)\ \ kw/ft}{Average\ kw/ft}$$


(6.0,1.0)
(11.0,0.94)
(12.0,0.66)
Uncover first
Recover last
Small
LOCA
K (Z) CORRECTION TERM
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1
2
3
4
5
6
7
8
9
10
11
12
CORE HEIGHT (FT)



1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
K(Z) - NORMALIZED PEAKING FACTOR
F_Q = 2.50
CORE HEIGHT
K(Z)
0.000 1.000
6.000 1.000
12.000 0.925
0
2.0
4.0
6.0
8.0
10.0
12.0
CORE HEIGHT (ft)

Nuclear Enthalpy Rise HCF

- The nuclear enthalpy rise hot channel factor, is defined as the ratio of the maximum integrated rod power to the average integrated rod power.

- **Purpose is to prevent localized DNB**.

- Measured periodically using incore flux detectors.

Quadrant Power Tilt Ratio

- Quadrant Power Tilt Ratio (QPTR) is the ratio of the maximum upper excore detector calibrated output to the average of the upper excore detector calibrated outputs, or the ratio of the maximum lower excore detector calibrated output to the average of the lower excore detector calibrated outputs, whichever is the greatest.

$$QPTR = \frac{\text{Max Upper (or Lower) Excore Detector Current}}{\text{Ave Upper (or Lower) Excore Detector Currents}}$$

Axial Flux Difference (AFD)

$\Delta I = \phi_T - \phi_B$

$Where:$

$\Delta I = Axial\ Flux\ Difference$

$\phi_T = Flux\ Signal\ from\ the\ top\ 1/2\ of\ power\ range\ \det ector$

$\phi_B = Flux\ Signal\ from\ the\ bottom\ 1/2\ of\ power\ range\ \det ector$

$Where\ \phi\ is\ \exp ressed\ as\ \%\ RTP$

Relaxed AFD Limits