Reactor Energy Removal

열제거 (Reactor Energy Removal)

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Table 7-1 , Power Densities for the Reference Reactor and Other System

System	Power density (KW/liter)		
	Core average	Fuel average	Fuel maximum
Fossil-fuel plant	10	-	-
Aircraft turbine	45	-	-
Rocket	20,000	-	-
HTGR	8.4	44	125
CANDU	12	110	190
BWR	56	56	180
PWR	95-105	95-105	190-210
LMFBR	280	280	420

Table 7-2. Power Peaking Factors for Reactors of Various Geometric Shapes

Geometry	Peaking factor	
	Total	Constituents
Sphere, bare	3.29	
Infinite slab, bare	1.57	
Cuboid, bare	3.87	x = 1.57
		y = 1.57
		z = 1.57
Infinite cylinder, bare	2.32	
Cylinder, bare	3.64	r = 2.32
		z = 1.57
Cylinder, fully reflected	2.03	r = 1.50
		z = 1.35
Cylinder, fully reflected	1.62	r = 1.20
Enrichment-zoned radially		Z = 1.35

Figure 7-1 Flux shape and Power density

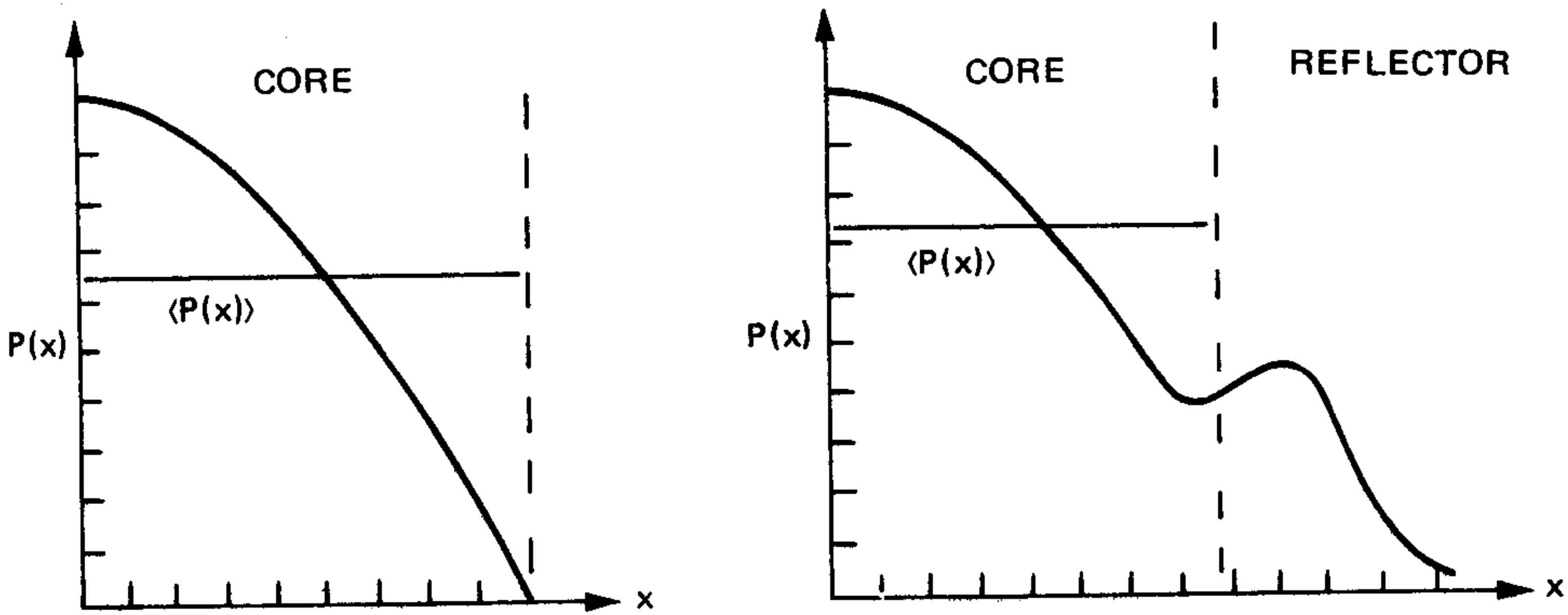


FIGURE 7-1
Flux shapes and average power densities for bare and reflected slab geometries.

Figure 7-2 Power distribution

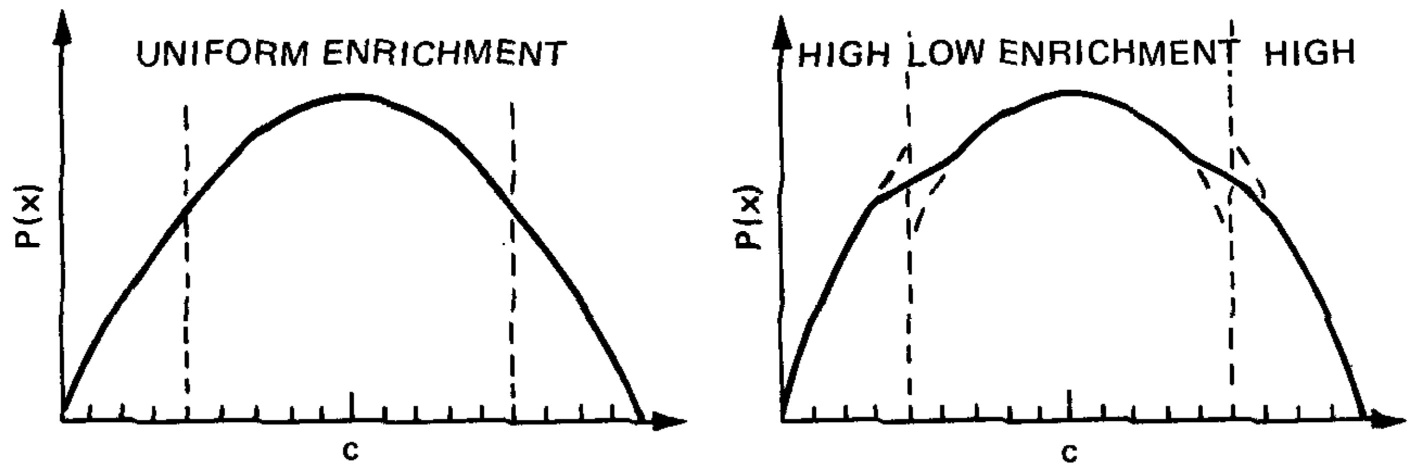


FIGURE 7-2
Power distributions for one- and two-batch fuel-management patterns in a *bare-slab geometry*.

Figure 7-3 Cross section

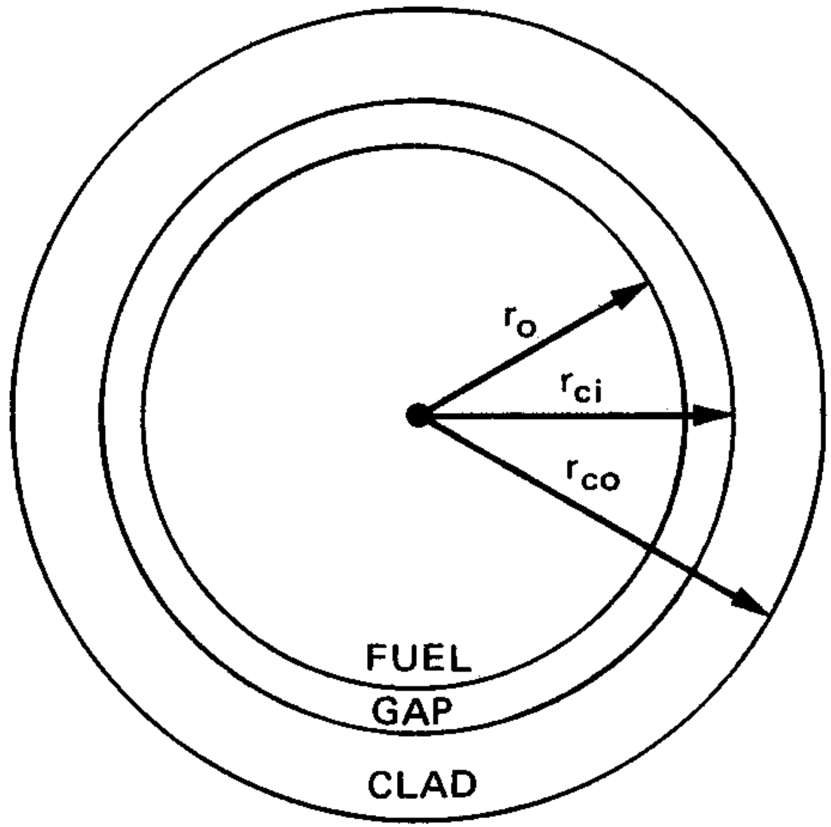


FIGURE 7-3
Cross section of a typical fuel pin (not drawn to scale).

Figure 7-4 Temperature profile

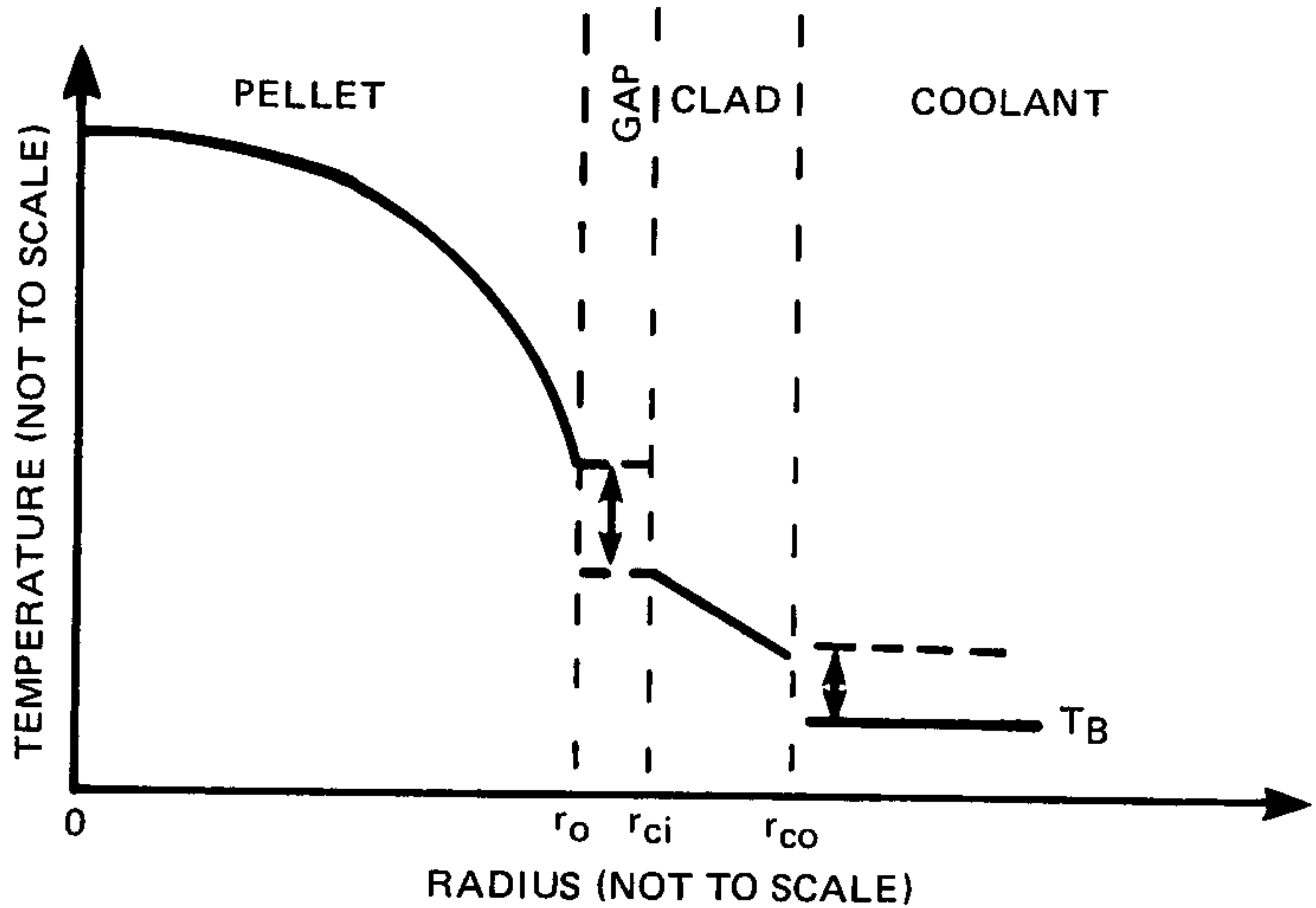


FIGURE 7-4
Basic features of the temperature profile across a clad fuel pin.

Figure 7-5 Axial Temperature profiles

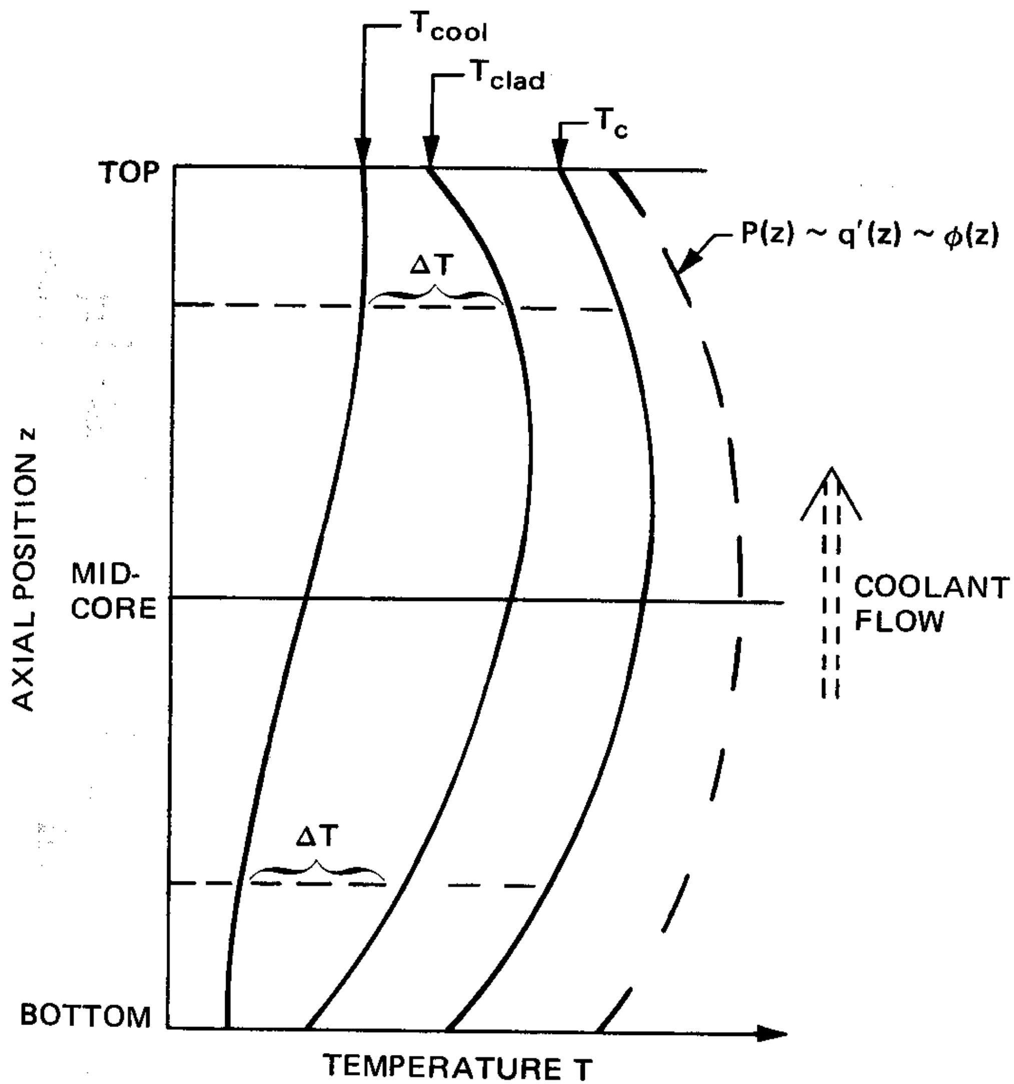


FIGURE 7-5
Axial temperature profiles for the fuel pellet center line, the clad, and the coolant in a reactor with a cosine flux distribution.

Figure 7-6 Heat flux vs. surface temp.

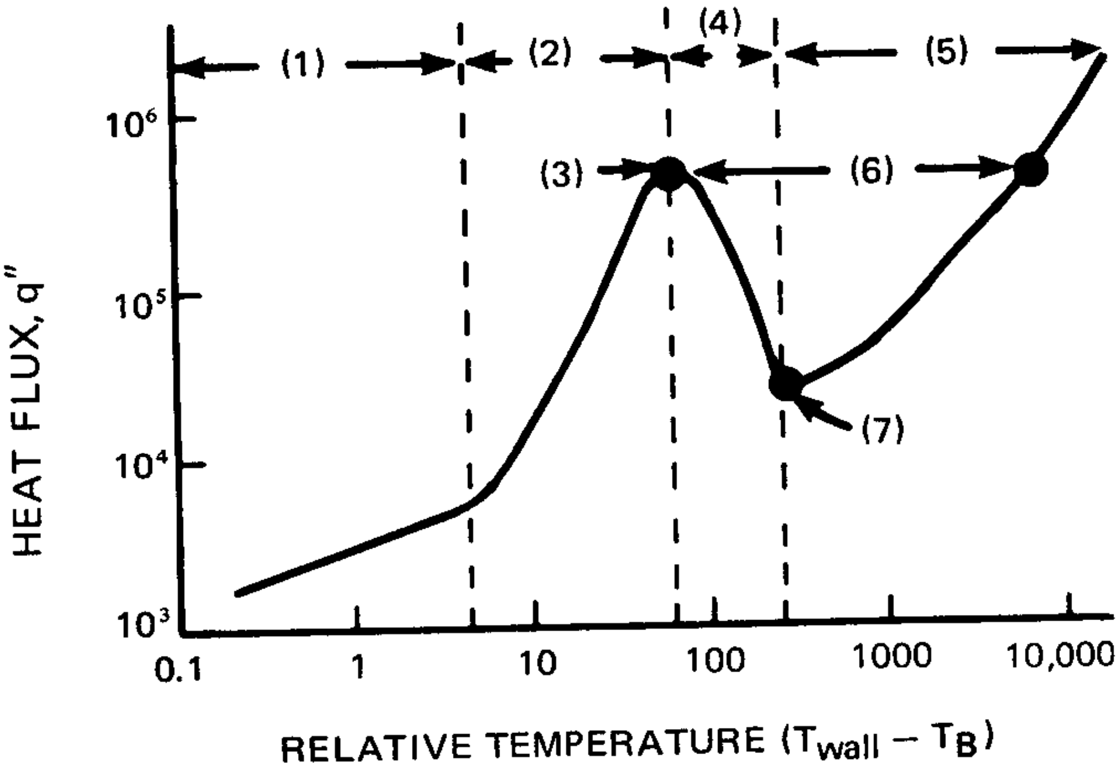


FIGURE 7-6
Heat flux versus surface temperature for a heated pin in a pool of water at saturation temperature.

Figure 7-7 Critical heat flux effects

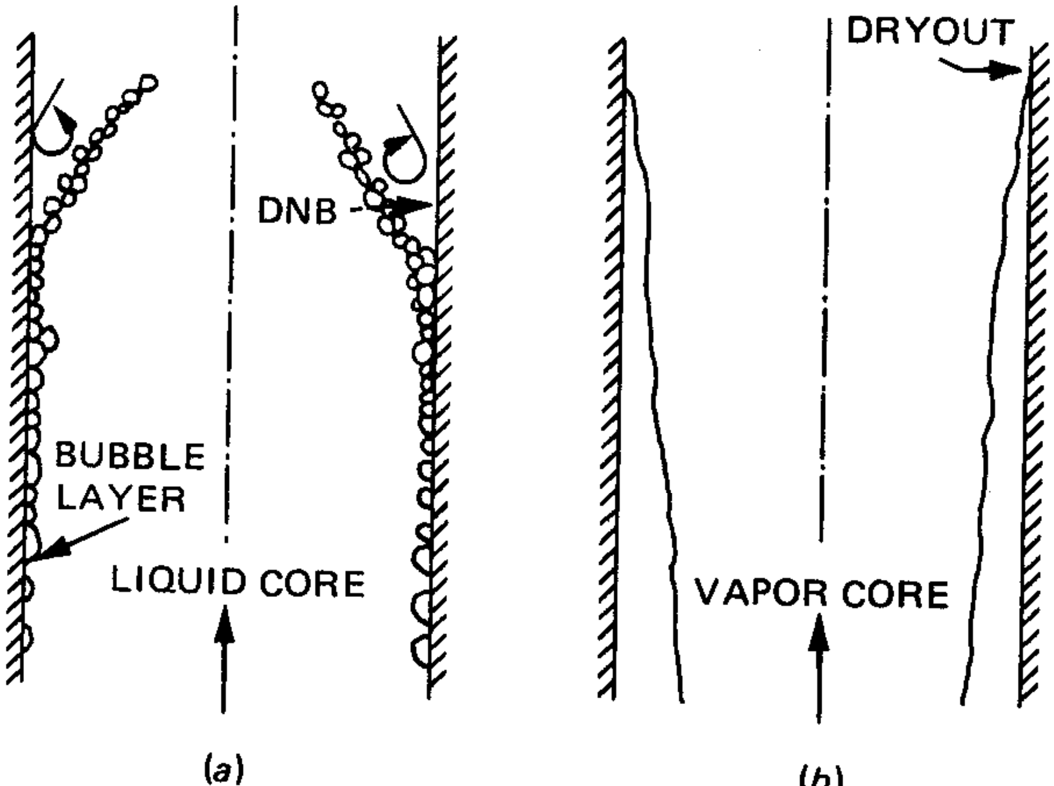


FIGURE 7-7
Critical heat flux effects for (*a*) pressurized and (*b*) boiling coolants. (Adapted from L. S. Tong, *Boiling Crises and Critical Heat Flux*, U.S.A.E.C., TID-25887, 1972.)

Figure 7-8 Characteristic relationship

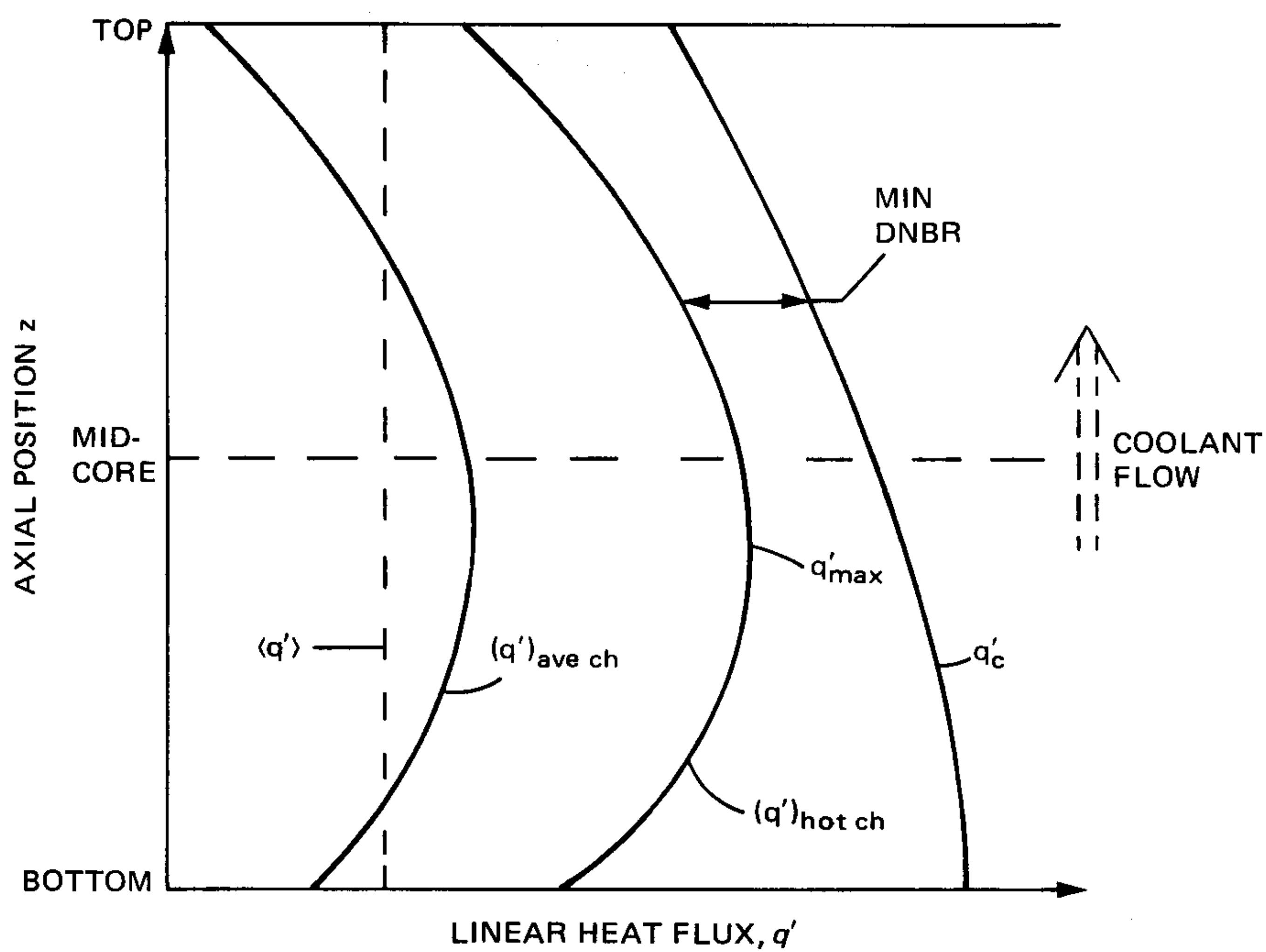


FIGURE 7-8
Characteristic relationship between the core average $\langle q' \rangle$, average channel $(q')_{\text{ave ch}}$, hot channel $(q')_{\text{hot ch}}$, and critical q'_c linear heat rates along the core axis of a PWR.

Figure 7-9 Effect CR Insertion (Axially)

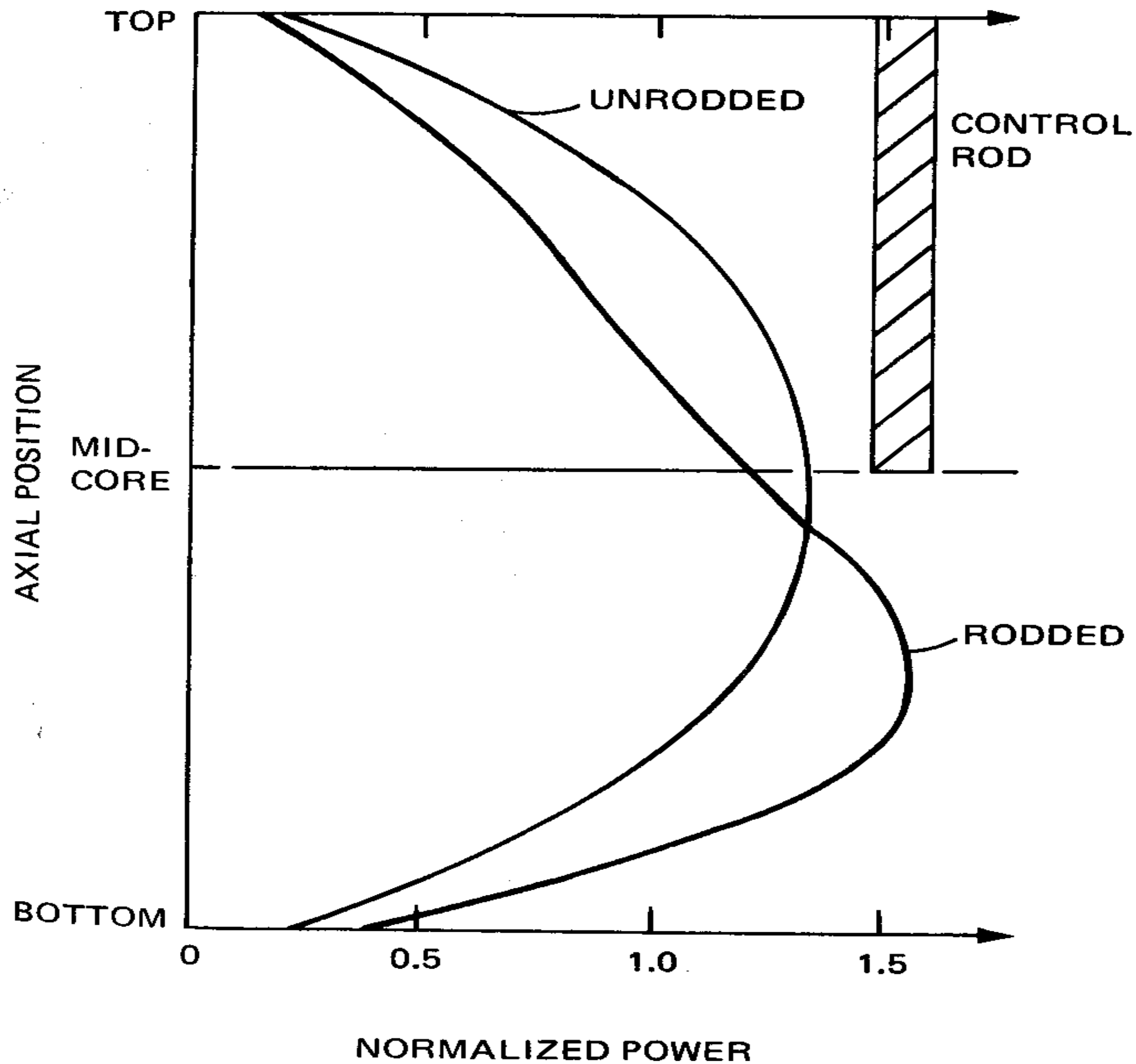


FIGURE 7-9
Effect of control-rod group insertion on PWR power shape axially for the core as a whole.

Figure 7-10 Effect CR Insertion (Radially)

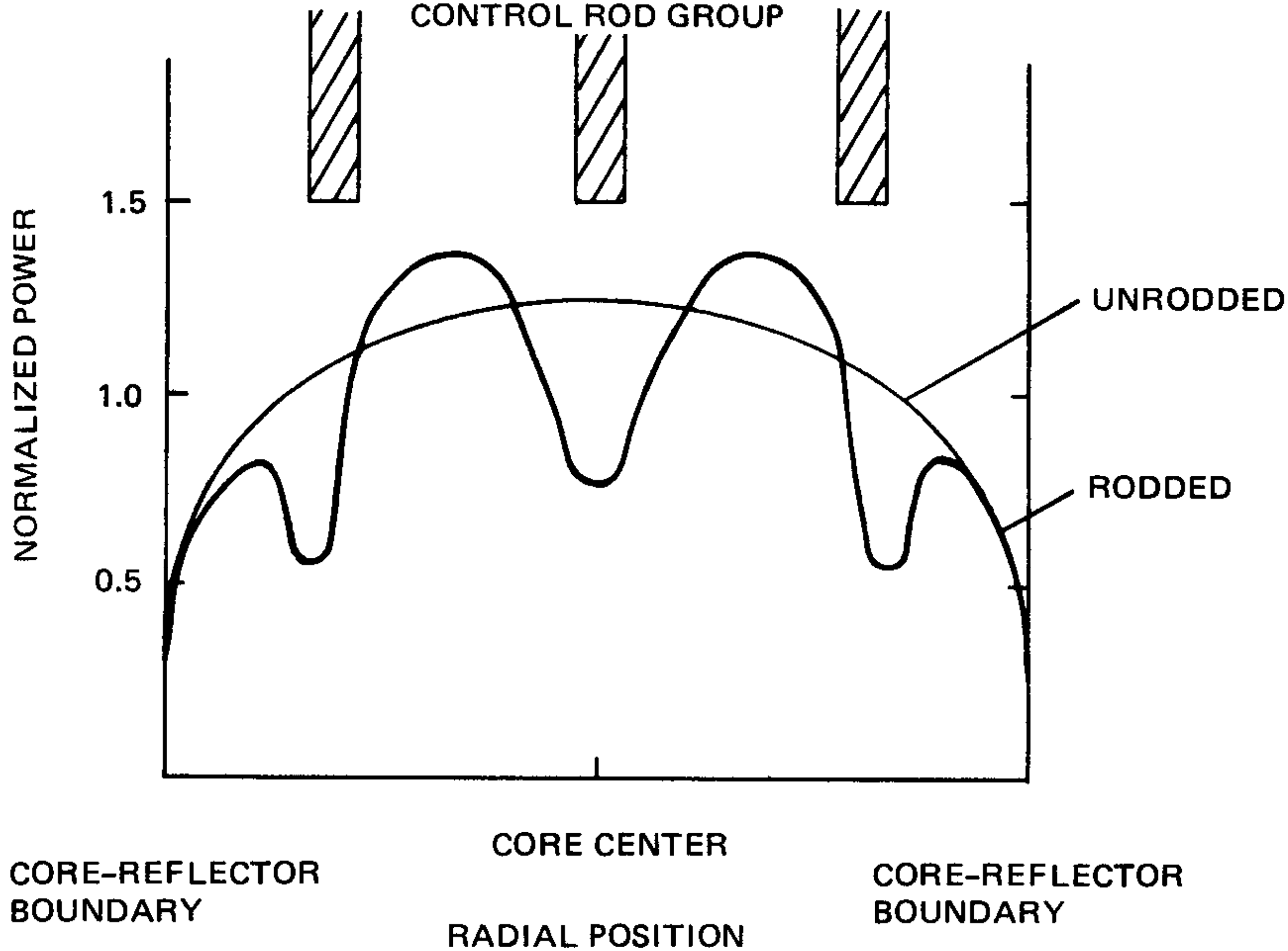


FIGURE 7-10
Effect of control-rod group insertion on PWR power shape radially in a plane through the control rods.

Figure 17-10 Annular containment structure(LMFBR)

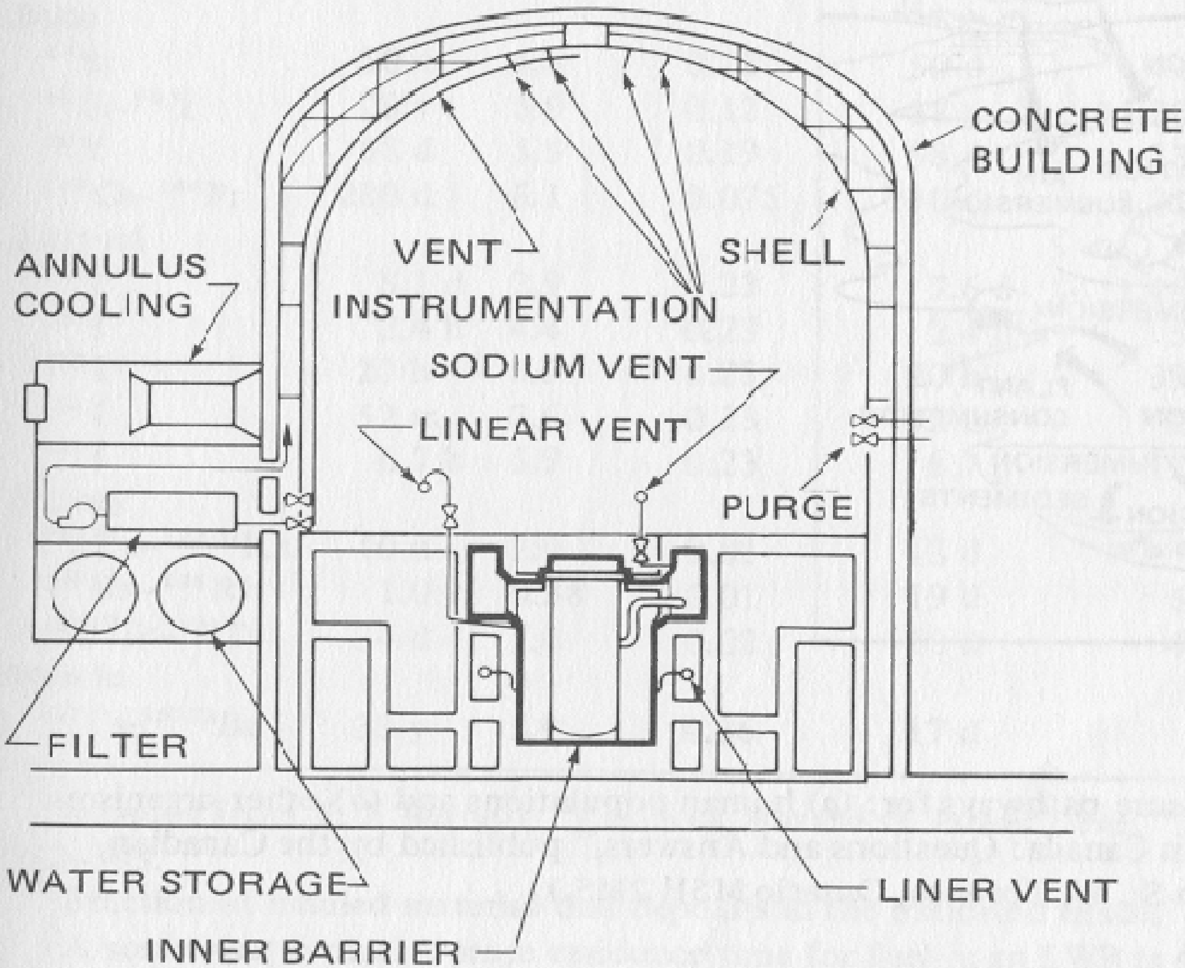
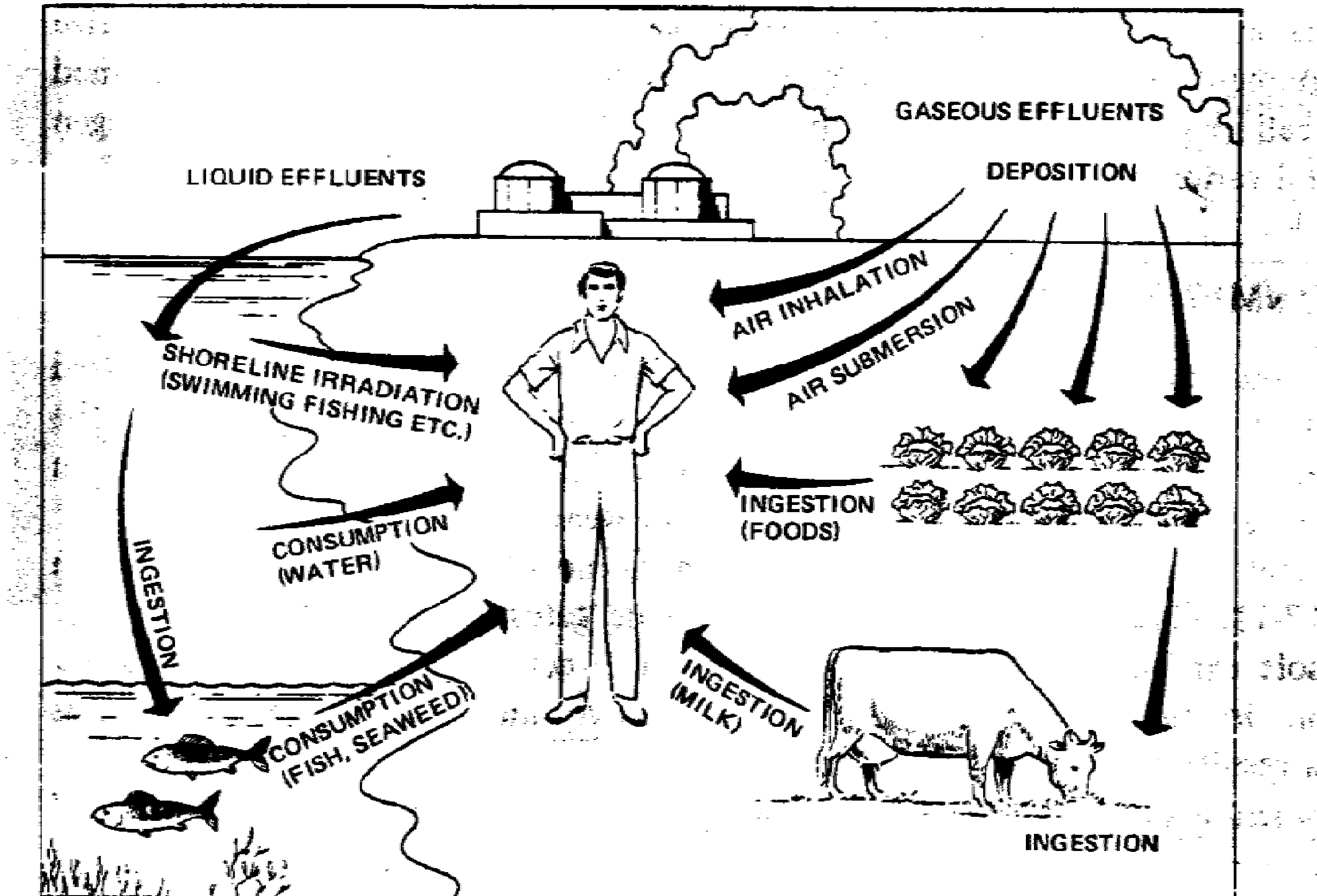


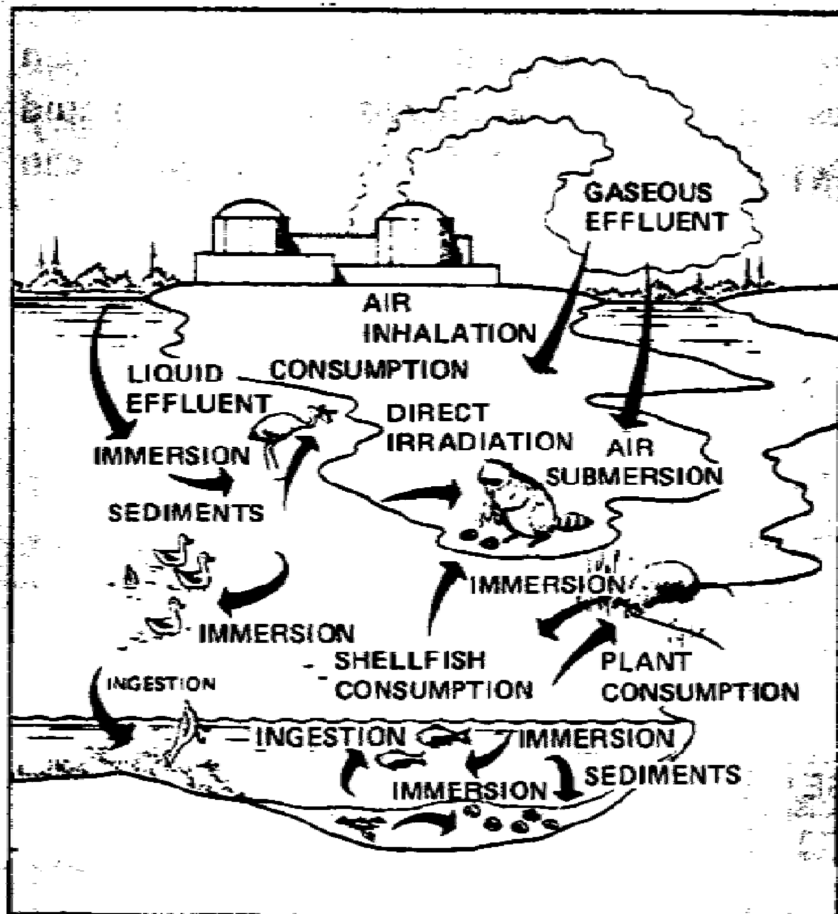
FIGURE 17-10
Annular containment structure for an LMFBR. (Courtesy of Clinch River Breeder Reactor Plant.)

Figure 17-11(a) Radionuclide exposure pathways(Human)



(a)

Figure 17-11(b) Radionuclide exposure pathways (Other)



(*b*)

FIGURE 17-11
Generalized radionuclide exposure pathways for: (*a*) human populations and (*b*) other organisms. (Courtesy of "Nuclear Power in Canada: Questions and Answers," published by the Canadian Nuclear Association, 65 Queen St. W, Toronto, Ontario M5H 2M5.)

Table 17-1 , Fission Products of Significance in Internal Exposure from Reactor Accidents

TABLE 17-1
Fission Products of Significance in Internal Exposure from Reactor Accidents†

Isotope	Radio-active half-life $T_{1/2}$	Fission *yield* (%)	Deposi-*tion* fraction‡	*Effective* half-life	Internal dose (*mrem*/ μCi)	Reactor inventory§ [Ci/kW(th)]	
						400 Days	Equilibrium
Bone							
^{89}Sr	50 d	4.8	0.28	50 d	413	43.4	43.6
^{90}Sr–^{90}Y	28 y	5.9	0.12	18 y	44,200	1.45	53.6
^{91}Y	58 d	5.9	0.19	58 d	337	53.2	53.6
^{144}Ce–^{144}Pr	280 d	6.1	0.075	240 d	1,210	34.7	55.4
Thyroid							
^{131}I	8.1 d	2.9	0.23	7.6 d	1,484	26.3	26.3
^{132}I	2.4 h	4.4	0.23	2.4 h	54	40.0	40.0
^{133}I	20 h	6.5	0.23	20 h	399	59.0	59.0
^{134}I	52 m	7.6	0.23	52 m	25	69.0	69.0
^{135}I	6.7 h	5.9	0.23	6.7 h	124	53.6	53.6
Kidney							
^{103}Ru–^{103m}Rh	40 d	2.9	0.01	13 d	6.9	26.3	26.3
^{106}Ru–^{106}Rh	1.0 y	0.38	0.01	19 d	65	1.8	3.5
^{129m}Te–^{129}Te	34 d	1.0	0.02	10 d	46	9.1	9.1
Muscle							
^{137}Cs–^{137m}Ba	33 y	5.9	0.36	17 d	8.6	1.2	53.6

†Adapted from T. J. Burnett, "Reactors, Hazard vs. Power Level," *Nucl. Sci. Eng.*, vol. 2, 1957, pp. 382–393.

‡Fraction of inhaled material that deposits in the indicated tissue.

§A somewhat typical average residence time for fuel in an LWR is 400 full-power days; equilibrium inventories are achieved at times that are long compared to the radionuclide half life.