(19.3) Compare two 500 MWe electric power stations, one burning oil and the other using 3.0% enriched uranium. Both stations operate 6000 h y^{-1} at 35% efficiency (heat to electricity). The oil (43.5 MJ/kg combustion energy) is carried by 100000 ton d.w. (dead weight, i.e. carrying capacity) oil tankers, and the uranium fuel by train cars of 20 t capacity each. Answer the following questions: (a) How many oil tankers will be needed every year for the oil-fired station? How many train cars will be needed every year for the nuclear power station for transporting (b) the enriched UO_2 reactor fuel, (c) the corresponding amount of natural uranium as U_3O_8 to the isotope enrichment plant, if the tail is 0.35% in ^{235}U? (See Ch. 2 and §19.9.) Reactor fuel rating 40000 $MW_{th}d/t$ U.

Data given in the text:

$Q_{oil} := 43.5 \cdot 10^6 \cdot joule \cdot kg^{-1}$ $\quad Q_{gen} := \frac{500 \cdot 10^6 \cdot 6000 \cdot 60 \cdot 60}{0.35} \cdot joule \cdot yr^{-1}$

$m_{oil} := \frac{Q_{gen}}{Q_{oil}}$ $\quad m_{oil} = 22.479 \cdot kg \cdot sec^{-1}$

(a) Oil tankers:

$m_{tanker} := 100000 \cdot 10^3 \cdot kg$ $\quad tankers := \frac{m_{oil}}{m_{tanker}}$ $\quad tankers = 7.1 \cdot yr^{-1}$

Rounded to 7 per year

(b) Train cars with enriched fuel:

$Q_{Ufuel} := \frac{40000 \cdot 10^6 \cdot 24 \cdot 60 \cdot 60}{10^3} \cdot joule \cdot kg^{-1}$

$m_{Ufuel} := \frac{Q_{gen}}{Q_{Ufuel}}$ $\quad m_{Ufuel} = 8.929 \cdot 10^3 \cdot kg \cdot yr^{-1}$

$m_{traincar} := 20 \cdot 10^3 \cdot kg$ $\quad traincars := \frac{m_{Ufuel}}{m_{traincar}}$ $\quad traincars = 0.446 \cdot yr^{-1}$

This means 1 per year

(c) Train cars with U_3O_8:

$x_p := 3 \cdot \%$ $\quad x_w := 0.35 \cdot \%$ $\quad x_f := 0.72 \cdot \%$

$Feed := m_{Ufuel} \cdot \frac{x_p - x_w}{x_f - x_w}$

$M_{wU} := 238.03 \cdot gm \cdot mole^{-1}$ $\quad M_{wO} := 16.00 \cdot gm \cdot mole^{-1}$ $\quad M_{wU3O8} := 3 \cdot M_{wU} + 8 \cdot M_{wO}$

$m_{U3O8} := Feed \cdot \frac{M_{wU3O8}}{3 \cdot M_{wU}}$ $\quad m_{U3O8} = 7.541 \cdot 10^4 \cdot kg \cdot yr^{-1}$

$feedtraincars := \frac{m_{U3O8}}{m_{traincar}}$ $\quad feedtraincars = 3.771 \cdot yr^{-1}$ This means 4 per year