22.312 ENGINEERING OF NUCLEAR REACTORS

Problem 3-6N

Energy sources in case of a large-break LOCA in a typical PWR

Compute the energy sources in a typical PWR, which the containment might have to accommodate.

1. Stored energy in primary coolant. Should enthalpy or internal energy be used?

2. Stored energy in secondary side of the steam generator.

3. Decay Heat – integrated release over a one hour shutdown period after infinite operation.

4. Chemical Reactions –

    a. Reaction of 75% of the zirconium clad with water coolant.
    b. Reaction of 25% of the zirconium clad with CO_2. Assume this reaction is constrained only by amount of zirconium available.

5. Combustion of hydrogen product in (4a) above.

Assumptions
Primary System: 306 m^3 of coolant at 15.5 MPa and 305°C
Secondary System: 89 m^3 of saturated liquid at 5.7 MPa
Reactor Power: 3411 MW_{th}
Number of 17x17 fuel assemblies: 193
Fuel pin geometry: 9.5 mm (OD), 0.57 mm (clad thickness), 4 m (length)

Chemical Reactions
$Zr + 2H_2O \rightarrow ZrO_2 + 2H_2 + 6.057x10^5$ J/mol of Zr
$Zr + CO_2 \rightarrow ZrO_2 + C + 7.05x10^5$ J/mol of Zr
$H_2 + 1/2O_2 \rightarrow H_2O + 2.4x10^5$ J/mol of H_2