Analysis of cooling flow through 29 fuel elements with fuel element 1175 dislodged

Normal flow through the reactor is 9000 gpm, flowing through 30 fuel elements. Per SAR 4.6.1.1, flow is divided as follows:

Inner plenum flow total	2300 gpm
Number of inner plenum elements	6
Flow through each inner plenum element	383 gpm
Outer plenum total flow	6400 gpm
Number of outer plenum elements	24
Flow through each outer plenum element	267 gpm

Approximate pressure drop through the fuel elements during normal operation is ~ 14.7 psid. Calculate the equivalent Cv for the fuel elements as per equation (1):

For a valve

$$Q = 7.9 * C_v * \sqrt{\frac{\Delta P}{\rho}} \quad (1)$$

Where

Q_{inner} = 383 gpm
ΔP = ~ 14.7 psid
ρ_{D2O} = 68.7 lb/ft^3

Cv = 104.9

Q_{outer} = 267 gpm
ΔP = ~ 14.7 psid
ρ_{D2O} = 68.7 lb/ft^3

Cv = 73.0

With element 1175 dislodged from its spot on the lower grid plate, the open orifice diameter is 2.378 in. Element 1175 was located on the outer plenum
The flow through an orifice is calculated in equation (2).
For an orifice

$$Q = 236 * {d_0}^2 * C * \sqrt{\frac{\Delta P}{\rho}} \quad (2)$$

Where

d_0 = 2.78 inch
C = 0.6

With element 1175 dislodged, total flow through the reactor remains the same (9000 gpm total). Total flow is divided between the 29 fuel elements in place and the one open orifice exposed by 1175 being removed. That is:

$$Q_{total} = 23 * Q_{fuel\ element\ (outer\ plenum)} + 6 * Q_{fuel\ element\ (inner\ plenum)} + Q_{1175\ orifice} \quad (3)$$

Plugging known Cv for the fuel elements, and using equations (1), (2) and (3), we get the following:

$Q_{fuel\ element\ inner}$ = 378.8 gpm

$Q_{fuel\ element\ outer}$ = 263.5 gpm

$Q_{1175\ orifice}$ = 366.1 gpm

Note that normally $Q_{\text{fuel element inner}}$ = 383 gpm and $Q_{\text{fuel element outer}}$ = 267 gpm, so the fact that fuel element 1175 was dislodged from its socket is inconsequential. Calculated pressure drop across the grid plate and fuel elements decreases from ~ 14.7 psid to ~ 14.4 psid.

Conclusion – there is no significant risk of other fuel elements having insufficient flow to remain cooled.

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