Appendix A

Systems Functional for Mitigation

Table A-1. Mitigation systems functional for use when a single or common mode IGSCC failure occurs during normal operating conditions without cascading effects.

Reactor Vessel Internal Components Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
In-Core Instrument Housing	—[a]	X	X	X	X	X	X	X	X	X	X
In-Core Instrument Guide Tube	X	X	X	X	X	X	X	X	X	X	X
IRM / SRM / LPRM Tube	—[a]	X	X	X	X	X	X	X	X	X	X
Core dP Line	X	X	X	X	X	X	X	X	X	X	X
SLC Line	X	X	X	X	X	X	X	X	X	—[j]	X
CRD Blade	—[b]	—[b]	X	X	X	X	X	X	X	X	X
CRD Housing	—[a,b]	—[b]	X	X	X	X	X	X	X	X	X
CRD Guide Tube	—[b]	—[b]	X	X	X	X	X	X	X	X	X
CRD Stub Tube	—[a,b]	—[b]	X	X	X	X	X	X	X	X	X
CRD Index Tube and Spud	—[b]	—[b]	X	X	X	X	X	X	X	X	X
CRD Thermal Sleeve	—[b]	—[b]	X	X	X	X	X	X	X	X	X
Fuel Support	—[b]	—[b]	X	X	X	X	X	X	X	X	X
Core Shroud Support					—[f]		—[f,g]	—[f,g,h]	—[f,g,i]	—[k]	X
Access Hole Cover	X	X	X	X	X	X	X	X	X	X	X
Core Plate			X	X	X	X	X	X	X	—[j]	X
Core Shroud					—[f]		—[f,g]	—[f,g,h]	—[f,g,i]	—[k]	X
Core Shroud Head		X	X	X	X	X	X	X	X	X	X
Core Shroud Head Bolt	—[b]	X	X	X	X	X	X	X	X	X	X
Guide Rod	X	X	X	X	X	X	X	X	X	X	X
Top Guide or Grid			X	X	X	X	X	X	X	X	X
Core Spray or LPCS Annulus Pipe	X	X	X	—[e]	X	X	X	X	X	—[l]	X

Table A-1. (continued).

Reactor Vessel Internal Components Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Core Spray or LPCS Inside Shroud (Sparger)	X	X	X	X[d]	X	X	X	X	X	X	X
HPCS Annulus Pipe	X	X		X	X	X	X	X	X	—[i]	X
HPCS Inside Shroud (Sparger)	X	X	X[d]	X	X	X	X	X	X	X	X
LPCI Coupling	X	X	X	X		X	X	X	X	X	X
LPCI Baffle or Flow Diverter	X	X	X	X	X	X	X	X	X	X	X
Feedwater Sparger	X[c]	X	X[c]	X	X	X[c]	X	X[c,h]	X[9]	X	X
Jet Pump Inlet Riser	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Riser Brace and Wedge and Restrainer	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Hold-Down Beam	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Transition Piece	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Inlet Elbow	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Nozzle	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Inlet Mixer or Throat	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Diffuser and Adapter	—[b]	X	X	X	—[g]	X	—[g]	—[g]	—[g,i]	X	X
Jet Pump Sensing Line	X	X	X	X	X	X	X	X	X	X	X
Standpipe	—[b]	X	X	X	X	X	X	X	X	X	X
Steam Separator	—[b]	X	X	X	X	X	X	X	X	X	X
Steam Dryer Assembly	X	X	X	X	X	X	X	X	X	X	X
Head Spray	X	X	X	X	X	X	X	X	X	X	X

Table A-1. (continued).

Reactor Vessel Internal Components Failure List	Systems Functional For Mitigation: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Surveillance Specimen Holder	X	X	X	X	X	X	X	X	X	X	X

Table Notes:

Reactor vessel internals not considered for IGSCC failure in this table include neutron source holders.

Recirc – recirculation

X- System is functional for mitigation purposes. Blank indicates system fails to function during normal operation.

a. Single failure includes a potential small break LOCA for which a normal shutdown is not considered available. Common mode failure may result in equivalent large break LOCA.

b. Single failure is not a significant concern, but with common mode failures, system fails to function.

c. Reduced dispersion but coolant flow still able to enter annulus.

d. Reduced spray effectiveness of spargers but coolant flow still able to enter inside core shroud.

e. For single failure, core spray reduced to half capacity. For common mode failure, core spray eliminated.

f. Core shroud support or core shroud failure eliminates the jet pumps which eliminate LPCI functionality on BWR/3s and 4s. On BWR/5s and 6s, core shroud support or core shroud failure eliminates LPCI since it penetrates through the core shroud.

g. IC is available through recirculation for BWR/2s and 3s. Shutdown cooling is available on BWR/2s, 3s, and 4s through recirculation and LPCI is available on BWR/3s and 4s through recirculation and RHR systems. For these systems, a single failure of a jet pump is not significant due to jet pump redundancy but common mode failures of jet pumps results in the loss of these systems. ECC low pressure flooding (LPCI) is not available on BWR/2s.

h. RCIC is available through feedwater for BWR/3s, 4s, 5s, and 6s.

i. RHR is available through feedwater for BWR/6s.

j. Eliminates functionality of SLC entering the lower plenum and supported off of the core shroud support and core shroud.

k. Eliminates functionality of SLC entering the lower plenum and supported off of the core shroud support and core shroud or entering through the core spray or HPCS lines.

l. Eliminates functionality of SLC entering through the core spray or HPCS lines.

Table A-2. Mitigation systems functional for use when a single or common mode IGSCC failure occurs during accident conditions without cascading effects.

Reactor Vessel Internal Components Failure List	BWR	Systems Functional For Mitigation Per Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
In-Core Instrument Housing	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
In-Core Instrument Guide Tube	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
IRM / SRM / LPRM Tube	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Core dP Line	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
SLC Line	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None[7]	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None[7]	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	None[7]	All
CRD Blade	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
CRD Housing	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All

Table A-2. (continued).

Reactor Vessel Internal Components Failure List	BWR	Systems Functional For Mitigation Per Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
CRD Guide Tube	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
CRD Stub Tube	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
CRD Index Tube and Spud	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
CRD Thermal Sleeve	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Fuel Support	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Core Shroud Support	2	None	None	None	None	N/A	A,C,H	None	A,B,D,E,F,H,K	None	None	All
	3	None	None	D, H, K	None	None	A,C,H	None	D, H, K	None	None	All
	4	None	None	D, H, K	None	None	H	None	D, H, K	None	None	All
	5	None	None	None	None	None	H	None	D, H, K	None	None	All
	6	None	None	None	None	None	H	None	D, H, K	A,C,D,E,G,H,K	None	All
Access Hole Cover	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Core Plate	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None[7]	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None[7]	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	None[7]	All

Table A-2. (continued).

Reactor Vessel Internal Components Failure List	BWR	Systems Functional For Mitigation Per Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Core Shroud	2	None	None	None	None	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	D, H, K	None	None	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None	All
	4	None	None	D, H, K	None	None	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None	All
	5	None	None	None	None	None	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	None	All
	6	None	None	None	None	None	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	None	All
Core Shroud Head	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Core Shroud Head Bolt	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Guide Rod	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Top Guide or Grid	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	None	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Core Spray or LPCS Annulus Pipe	2	None	A,B,C,D,E,F,G,K	None	None	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	None	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	None	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All[8]	All
	5	None	A,B,C,D,E,F,G,K	All	None	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	None	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Core Spray or LPCS Inside Shroud (Sparger)	2	None	A,B,C,D,E,F,G,K	None	1	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	1	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	1	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	1	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	1	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
HPCS Annulus Pipe (BWR/5s and 6s)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	A,B,C,D,E,F,G,K	None	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All[8]	All
	6	None	A,B,C,D,E,F,G,K	None	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All[8]	All

Table A-2. (continued).

Reactor Vessel Internal Components Failure List	BWR	Systems Functional For Mitigation Per Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
HPCS Inside Shroud (Sparger) (BWR/5s and 6s)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	A,B,C,D,E,F,G,K	2	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	2	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
LPCI Coupling (BWR/5s and 6s)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	A,B,C,D,E,F,G,K	All	All	None	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	None	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
LPCI Baffle (BWR/5s) or Flow Diverter (BWR/6s)	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Feedwater Sparger	2	None	A,B,C,D,E,F,G,K	None	All	N/A	4	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	3	All	A,B,D,E,F,H,K	4	A,B,D,E,F,H,K	3	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	3	All	A,B,D,E,F,H,K	5	A,B,D,E,F,H,K	3	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	5	A,B,D,E,F,H,K	3	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	5	A,B,D,E,F,H,K	3	6	All	All
Jet Pump Inlet Riser	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All
Jet Pump Riser Brace and Wedge and Restrainer	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All
Jet Pump Hold-Down Beam	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All
Jet Pump Transition Piece	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All

Table A-2. (continued).

Reactor Vessel Internal Components Failure List	BWR	Systems Functional For Mitigation Per Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Jet Pump Inlet Elbow	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All
Jet Pump Nozzle	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All
Jet Pump Inlet Mixer or Throat	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All
Jet Pump Diffuser and Adapter	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	None	A,C,H	None	D, H, K	None	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	None	H	None	D, H, K	None	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	None	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	None	D, H, K	A,C,D,E,G,H,K	All	All
Jet Pump Sensing Line	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Standpipe	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Steam Separator	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Steam Dryer Assembly	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	all

Table A-2. (continued).

Reactor Vessel Internal Components Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Initiating Event										
Head Spray	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All
Surveillance Specimen Holder	2	None	A,B,C,D,E,F,G,K	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	4	None	A,B,C,D,E,F,G,K	D, H, K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	5	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,B,D,E,F,H,K	All	All
	6	None	A,B,C,D,E,F,G,K	All	All	All	H	A,B,D,E,F,H,K	D, H, K	A,C,D,E,G,H,K	All	All

Table Notes:

Reactor vessel internals not considered for IGSCC failure in this table include neutron source holders.

Recirc – recirculation

None - Indicated system is not functional for any of the initiating events

N/A - Indicated component or system is not applicable to this BWR design

All - Indicated system is functional for all of the initiating events

Systems available per initiating event:
A-MSLB B-FWLB C-RLB D-SSE (during operation) E-MSLB + SSE F-FWLB + SSE G-RLB + SSE H-ATWS K-SSE (during refueling)

1 - Reduced spray effectiveness due to malfunction of sparger but coolant still enters inside core shroud for all of the initiating events.

2 - Reduced spray effectiveness due to malfunction of sparger but coolant still enters vessel annulus for all of the initiating events.

3 - Reduced spray effectiveness due to malfunction of sparger but coolant still enters vessel annulus for D,H, and K initiating events.

4 - Reduced spray effectiveness due to malfunction of sparger but coolant still enters vessel annulus for A,C, and H initiating events.

5 - Reduced spray effectiveness due to malfunction of sparger but coolant still enters vessel annulus for H initiating events only.

6 - Reduced spray effectiveness due to malfunction of sparger but coolant still enters vessel annulus for A,C,D,E,G,H, and K initiating events.

7 - SLC is available for those plants with SLC injecting through the core spray or HPCS lines.

8 - SLC is not available for those plants with SLC injecting through the core spray or HPCS lines.

Table A-3. Mitigation systems functional for use when a single or common mode IGSCC failure occurs during normal operating conditions with cascading effects.

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
In-Core Instrument Housing*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One housing breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
One housing breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts block coolant flow in no more than MANBC pathways		X	X	X	X	X	X	X	X	X	X
One housing breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of in-core instrument housings break with loss of RPV pressure boundary significantly challenging coolant makeup capabilities and potentially lowering core reflood levels, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	—[a]	X
In-Core Instrument Guide Tube*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One guide tube breaks, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
One guide tube breaks, loss of associated instrumentation results, and loose parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One guide tube breaks, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of guide tubes break, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
IRM / SRM / LPRM Tube*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One tube breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
One tube breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts block coolant flow in no more than MANBC pathways		X	X	X	X	X	X	X	X	X	X
One tube breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of tubes break with loss of RPV pressure boundary challenging coolant makeup capabilities, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Core dP Line*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Core dP line breaks, doesn't measure dP correctly and eliminates functionality of SLC line	X	X	X	X	X	X	X	X	X	—[b]	X
Core dP line breaks and eliminates functionality of SLC line, doesn't measure dP correctly, and parts jam more than MANNF CRDs			X	X	X	X	X	X	X	—[b]	X
Core dP line breaks and eliminates functionality of SLC line, doesn't measure dP correctly, and parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	—[b]	X
Core dP line breaks and eliminates functionality of SLC line, doesn't measure dP correctly, parts jam more than MANNF CRDs, and parts block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	—[b]	X
SLC Line*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
SLC line breaks and does not disperse SLC as intended but is still injected	X	X	X	X	X	X	X	X	X	X	X
SLC line breaks and eliminates functionality of core dP line	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
SLC line breaks, cannot inject SLC, and eliminates functionality of core dP line	X	X	X	X	X	X	X	X	X	—[b]	X
SLC line breaks, cannot inject SLC, eliminates functionality of core dP line, and parts jam more than MANNF CRDs			X	X	X	X	X	X	X	—[b]	X
SLC line breaks, cannot inject SLC, eliminates functionality of core dP line and parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	—[b]	X
SLC line breaks, cannot inject SLC, eliminates functionality of core dP line, parts jam more than MANNF CRDs, and parts block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	—[b]	X
CRD Blade*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One control rod blade deforms, jams that CRD and blocks coolant flow	X	X	X	X	X	X	X	X	X	X	X
One control rod blade deforms, jams that CRD and blocks coolant flow and other parts break off and jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One control rod blade deforms, jams that CRD and blocks coolant flow and other parts block coolant flow in no more than MANBC total pathways	X	X	X	X	X	X	X	X	X	X	X
One control rod blade deforms, jams that CRD and blocks coolant flow, other parts break off and jam more than MANNF other CRDs, and other parts block coolant flow in no more than MANBC total pathways			X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of control rod blades deform and their insertion or withdrawal is eliminated, and coolant flow is blocked in more than MANBC pathways			X	X	X	X	X	X	X	X	X
CRD Housing*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One housing breaks and does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	X	X	X	X	X	X	X	X	X	X	X
One housing breaks and does not support fuel support piece and fuel assembly and single control rod drops	X	X	X	X	X	X	X	X	X	X	X
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single CRD insertion or withdrawal results, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts block coolant flow in no more than MANBC pathways		X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts block coolant flow in no more than MANBC pathways		X	X	X	X	X	X	X	X	X	X
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of CRD housings break with loss of RPV pressure boundary significantly challenging coolant makeup capabilities and potentially lowering core reflood levels, fuel support pieces and fuel assemblies are not properly supported, more than MANNF control rods drop and/or the loss of functionality of more than MANNF CRDs result, and coolant flow is blocked in no more than MANBC pathways			X	X	X	X	X	X	X	—[a]	X
CRD Guide Tube*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One guide tube breaks and does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	X	X	X	X	X	X	X	X	X	X	X
One guide tube breaks and does not support fuel support piece and fuel assembly, loss of single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One guide tube breaks and does not support fuel support piece and fuel assembly, loss of single control rod insertion or withdrawal results, and loose parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One guide tube breaks and does not support fuel support piece and fuel assembly, loss of single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of guide tubes break and do not support fuel support pieces and fuel assemblies, loss of the functionality of more than MANNF CRDs result, and coolant flow is blocked in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
CRD Stub Tube*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One CRD stub tube breaks and does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	X	X	X	X	X	X	X	X	X	X	X
One CRD stub tube breaks and does not support fuel support piece and fuel assembly and single control rod drops	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts block coolant flow in no more than MANBC pathways		X	X	X	X	X	X	X	X	X	X
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts block coolant flow in no more than MANBC pathways		X	X	X	X	X	X	X	X	X	X
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of CRD stub tubes break with loss of RPV pressure boundary significantly challenging coolant makeup capabilities and potentially lowering core reflood levels, fuel support pieces and fuel assemblies are not properly supported, more than MANNF control rods drop and/or the loss of more than MANNF CRDs result, and loose parts block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	—[a]	X
CRD Index Tube and Spud*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One CRD index tube or spud breaks and single control rod cannot insert or withdraw	X	X	X	X	X	X	X	X	X	X	X
One CRD index tube or spud breaks and lets single control rod drop	X	X	X	X	X	X	X	X	X	X	X
One CRD index tube or spud breaks, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One CRD index tube or spud breaks, single control rod drops, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One CRD index tube or spud breaks, single control rod cannot insert or withdraw, and loose parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One CRD index tube or spud breaks, single control rod drops, and loose parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One CRD index tube or spud breaks, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
One CRD index tube or spud breaks, single control rod drops, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of CRD index tubes or spuds break, more than MANNF control rods drop and/or the loss of functionality results, and loose parts block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
CRD Thermal Sleeve*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One thermal sleeve breaks and single control rod cannot insert or withdraw	X	X	X	X	X	X	X	X	X	X	X
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	X	X	X	X	X	X	X	X	X	X	X
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs			X	X	X	X	X	X	X	X	X
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly, single control rod cannot insert or withdraw, and loose parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of thermal sleeves break and guide tubes do not support fuel support pieces and fuel assemblies, more than MANNF control rods cannot insert or withdraw, and loose parts block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Fuel Support*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
One fuel support breaks which does not support the adjacent fuel assemblies, prevents single control rod insertion or withdrawal, and coolant is blocked in that one location	X	X	X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of fuel supports break displacing the fuel assemblies, some significant number of control rods cannot insert or withdraw, and coolant flow is blocked around fuel assemblies			X	X	X	X	X	X	X	X	X
Core Shroud Support											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Core shroud support breaks, allowing coolant leakage to flow from lower plenum to annulus	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
	Systems Functional For Mitigation										
Core shroud support breaks, displacing the core shroud, core plate, nuclear core, top guide, core shroud head, steam separators, steam dryers, and other internals attached to the core shroud support or core shroud, blocking coolant flow, eliminating the functionality of some significant number of control rods, jet pumps, feedwater spargers, SLC, core spray (including LPCS and HPCS) and LPCI lines which penetrate the core shroud											X
Access Hole Cover*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Access hole cover breaks and allows coolant leakage from lower plenum to annulus	X	X	X	X	X	X	X	X	X	X	X
Common Mode: All access hole covers break and allow coolant leakage from lower plenum to annulus	X	X	X	X	X	X	X	X	X	X	X
Core Plate											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Core plate breaks and tilts or partially displaces the nuclear core, eliminating the functionality of some significant number of control rods and creating coolant flow blockage			X	X	X	X	X	X	X	X	X
Core plate breaks off from core shroud support ledge, displacing the nuclear core, creating coolant flow blockage, and eliminating the functionality of SLC and some significant number of control rods			X	X	X	X	X	X	X	—[b]	X
Core Shroud											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Core shroud breaks allowing coolant leakage from inside shroud to annulus	X	X	X	X	X	X	X	X	X	X	X
Core shroud breaks and displaces, deforming the core, blocking coolant flow, and eliminating the functionality of some significant number of control rods			X	X	X	X	X	X	X	X	X
Core shroud breaks and displaces, deforming the core, blocking coolant flow, and eliminating the functionality of some significant number of control rods and jet pumps			X	X	—[c]	X		—[d]	—[e]	X	X
Core shroud breaks, displacing vertically and laterally deforming the core, preventing control rod insertion or withdrawal, eliminating the functionality of feedwater spargers, SLC, core spray (including LPCS and HPCS) and LPCI lines which penetrate the core shroud and blocking coolant flow					—[f]		X	—[g]	X —[h]		X
Core shroud breaks, displacing vertically and laterally, deforming the core, preventing control rod insertion or withdrawal, eliminating the functionality of jet pumps, feedwater spargers, SLC, core spray (including LPCS and HPCS) and LPCI lines which penetrate the core shroud, and blocking coolant flow											X
Core Shroud Head											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Core shroud head breaks, displacing vertically and laterally, allowing coolant leakage from inside shroud to annulus, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path		X	X	X	X	X	X	X	X	X	X
Core shroud head breaks, displacing vertically and laterally, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation		X			—[f]		X	—[g]	X —[h]	X —[i]	X
Core shroud head breaks, displacing vertically and laterally, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path		X			—[f]		X	—[g]	X —[h]	X —[i]	X
Core Shroud Head Bolt*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation									
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of core shroud head bolts break, displacing core shroud head, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path		X			_[f]		X	_[g]	X _[h]	X _[i]	X
Guide Rod*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Common Mode: All guide rods break	X	X	X	X	X	X	X	X	X	X	X
Top Guide or Grid											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Top guide breaks, displacing laterally and vertically deforming the fuel assemblies, blocking coolant flow, and eliminating the functionality of some significant number of control rods			X	X	X	X	X	X	X	X	X
Top guide breaks, displacing laterally and vertically deforming the fuel assemblies, blocking coolant flow, and eliminating the functionality of some significant number of control rods and the functionality of core spray (including LPCS and HPCS) and LPCI lines inside the core shroud			_[j]		_[f]	X	X	X	X	X _[i]	X
Core Spray or LPCS Annulus Pipe*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Core spray line breaks, reducing flow of core spray system inside core shroud by half or eliminating LPCS flow inside core shroud	X	X	X	—[k,l]	X	X	X	X	X	X —[i]	X
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud	X	X	X		X	X	X	X	X	X —[i]	X
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud, and eliminating functionality of feedwater spargers		X			X		X	—[g]	X	X	X
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud, and eliminating the functionality of jet pumps		X	X			X		—[d]		X	X
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud, and eliminating the functionality of feedwater spargers and jet pumps		X								X	X
Core Spray or LPCS Inside Shroud (Sparger)*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Single core spray [or LPCS sparger] breaks, reducing effectiveness of that ECC core spray pattern and impacting the other core spray sparger [or HPCS sparger] and eliminating that ECC flow path	X	X	—[j]	—[k,m]	X	X	X	X	X	X —[i]	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Single core spray [or LPCS sparger] breaks, reducing effectiveness of that ECC core spray pattern, impacting top guide, deforming a single control rod and a single fuel assembly, and blocking coolant flow at that location	X	X	X	—[m]	X	X	X	X	X	X	X
Common Mode: Excluding the LPCS sparger, both core spray spargers break reducing effectiveness of ECC core spray patterns but ECC still enters inside the core shroud	X	X	X	—[m]	X	X	X	X	X	X	X
Common Mode: Excluding the LPCS sparger, both core spray spargers break, reducing the effectiveness of ECC core spray patterns but ECC still enters inside the core shroud and both core spray spargers impact the top guide, moving or deforming fuel assemblies, damaging more than MANNF control rods, and blocking coolant flow in no more than MANBC pathways			X	—[m]	X	X	X	X	X	X	X
HPCS Annulus Pipe (BWR/5s and 6s)*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
HPCS line breaks, eliminating HPCS flow inside core shroud	X	X		X	X	X	X	X	X	X —[i]	X
HPCS Inside Shroud (Sparger) (BWR/5s and 6s)*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
HPCS sparger breaks, reducing effectiveness of ECC high pressure core spray patterns, and impacts the LPCS sparger, eliminating that ECC flow path	X	X	—[m]	—[l]	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
HPCS sparger breaks, reducing effectiveness of ECC high pressure core spray patterns, impacting top guide and deforming a single control rod and a single fuel assembly, blocking coolant flow at that location	X	X	—[m]	X	X	X	X	X	X	X	X
Common Mode: Both LPCS and HPCS spargers break, reducing effectiveness of both ECC core spray patterns but ECC still enters inside the core shroud and both LPCS and HPCS spargers impact the top guide, moving or deforming fuel assemblies, damaging more than MANNF control rods, and blocking coolant flow in no more than MANBC pathways			—[m]	—[m]	X	X	X	X	X	X	X
LPCI Coupling (BWR/5s and 6s)*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Single LPCI coupling breaks, reducing LPCI flow inside core shroud	X	X	X	X	—[n]	X	X	X	X	X	X
Common Mode: Some significant number of LPCI couplings break, eliminating LPCI flow inside core shroud	X	X	X	X		X	X	X	X	X	X
Common Mode: Some significant number of LPCI couplings break, impacting some significant number of jet pumps and eliminating their functionality, allowing coolant leakage into annulus		X	X	X		X		X	—[e]	X	X
Common Mode: Some significant number of LPCI couplings break, impacting some significant number of the feedwater spargers, eliminating their functionality and allowing coolant leakage into annulus		X	X	X			X		X —[h]	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of LPCI couplings break, impacting LPCS, eliminating low pressure ECC spray into the core shroud and allowing coolant leakage into annulus	X	X	X			X	X	X	X	X[i]	X
Common Mode: Some significant number of LPCI couplings break, impacting HPCS, eliminating high pressure ECC spray into the core shroud and allowing coolant leakage into annulus	X	X		X		X	X	X	X	X[i]	X
Common Mode: Some significant number of LPCI couplings break, impacting the core shroud head bolts and displacing the core shroud head, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, LPCS, and HPCS lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path		X					X		X[h]	X[i]	X
LPCI Baffle (BWR/5s) or Flow Diverter (BWR/6s)*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Single LPCI baffle breaks, eliminating in-core instrumentation and impacts top guide, deforming a single control rod and a single fuel assembly, blocking coolant flow at that location	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Single LPCI flow diverter breaks, eliminating in-core instrumentation and flow diverter impacts, moves, and deforms adjacent fuel assemblies, deforms more than MANNF control rods, and blocks coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of LPCI baffles break, eliminating in-core instrumentation and baffles impact top guide, moving or deforming adjacent fuel assemblies, deforming more than MANNF control rods, and blocking coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of LPCI flow diverters break, eliminating in-core instrumentation and flow diverters impact and deform adjacent fuel assemblies, deforming more than MANNF control rods, and blocking coolant flow in more than MANBC pathways			X	X	X	X	X	X	X	X	X
Feedwater Sparger*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Sparger breaks off and impacts some significant number of the jet pumps, reducing their flow functionality, allowing coolant leakage into annulus		X	X	X	—[o]	—[p]	—[n]	—[d]	—[e,q]	X	X
Sparger breaks off and impacts adjacent standpipes, reducing their flow functionality and allowing coolant leakage to water-filled outside region	X	X	X	X	X	—[p]	X	X	X	X	X
Sparger breaks off, impacting adjacent core shroud head bolts, and displacing or perforating the core shroud head such that leakage from inside the core shroud to the annulus occurs	X	X	X	X	X	—[p]	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Sparger breaks off and impacts the steam dryer assembly, reducing its functionality and breaking the dryer seal skirt	X	X	X	X	X	—[p]	X	X	X	X	X
Common Mode: Some significant number of the feedwater spargers break, impacting the remaining feedwater spargers, eliminating their functionality		X	—[c]	X	X	—[n,p]	X	7	X / —[h]	X	X
Common Mode: Some significant number of feedwater spargers break, impacting some significant number of jet pumps and eliminating their functionality, allowing coolant leakage into annulus		X	—[j,p]	X	—[c]	—[p]		—[d]	—[e]	X	X
Common Mode: Some significant number of feedwater spargers break, impacting some significant number of the LPCI couplings, eliminating low pressure ECC flooding into the core shroud and allowing coolant leakage into annulus		X	—[p]	X	—[l]	—[p]	X	X	X	X	X
Common Mode: Some significant number of feedwater spargers break, impacting both core spray lines or LPCS, eliminating low pressure ECC spray into the core shroud and allowing coolant leakage into annulus		X	—[j,p]		X	—[p]	X	X	X	X / —[i]	X
Common Mode: Some significant number of feedwater spargers break, impacting HPCS, eliminating high pressure ECC spray into the core shroud and allowing coolant leakage into annulus		X	—[l]	X	X	—[p]	X	X	X	X / —[i]	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of feedwater spargers break, impacting the core shroud head bolts and displacing the core shroud head, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path		X	—[j,p]		—[f]	—[p]	X	X	X	X —[i]	X
Jet Pump Inlet Riser*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump inlet riser breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	X	X	X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of jet pump inlet risers break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow		X	X	X	—[c]	X		—[d]	—[c]	X	X
Common Mode: Some significant number of jet pump inlet risers break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow		X								X —[i]	X
Jet Pump Riser Brace and Wedge and Restrainer*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Jet pump riser brace or wedge and restrainer breaks and leads to failure of that jet pump	X	X	X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of jet pump riser braces and wedges and restrainers break, causing some significant number of inlet risers to break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow		X	X	X	—[c]	X		—[d]	—[e]	X	X
Common Mode: Some significant number of jet pump riser braces and wedges and restrainers break, causing some significant number of inlet risers to break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow		X								X —[f]	X
Jet Pump Hold-Down Beam*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	X	X	X	X	X	X	X	X	X	X	X
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, permitting the entire "ram's head" to displace, eliminating the functionality of a feedwater sparger located in the annulus		X	—[c]	X	X	—[n,p]	X	—[g]	X —[h]	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
	Systems Functional For Mitigation										
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, permitting the entire "ram's head" to displace, eliminating the functionality of core spray (including LPCS and HPCS) lines located in the annulus		X	—[f]		X	X	X	X	X	X —[l]	X
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, permitting the entire "ram's head" to displace, eliminating the functionality of the LPCI lines located in the annulus		X	X	X	—[f]	X	X	X	X	X	X
Common Mode: Some significant number of jet pump hold-down beams break, causing the associated "ram's heads" to break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow		X	X	X	—[c]	X		—[d]	—[e]	X	X
Common Mode: Some significant number of jet pump hold-down beams break, causing the associated "ram's heads" to break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps, and rerouting coolant flow		X								X —[l]	X
Jet Pump Transition Piece*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump transition piece breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of jet pump transition pieces break, causing the associated "ram's heads" to break, eliminating functionality of some significant number of jet pumps, rerouting coolant flow		X	X	X	—[c]	X		—[d]	—[e]	X	X
Common Mode: Some significant number of jet pump transition pieces break, causing the associated "ram's heads" to break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps and rerouting coolant flow		X								X —[f]	X
Jet Pump Inlet Elbow*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump inlet elbow breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	X	X	X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of jet pump inlet elbows break, rerouting coolant flow, and eliminating the functionality of some significant number of jet pumps		X	X	X	—[c]	X		—[d]	—[e]	X	X
Jet Pump Nozzle*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, and loose parts jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow, reducing coolant flow efficiency through the core, and loose parts block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow, reducing coolant flow efficiency through the core, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of jet pump nozzles break, causing failure of some significant number of jet pumps, rerouting coolant flow, reducing coolant flow efficiency through the core, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways			X	X	—[c]	X		—[d]	—[e]	X	X
Jet Pump Inlet Mixer or Throat*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump inlet mixer or throat breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	X	X	X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of jet pump inlet mixers or throats break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, reducing coolant flow efficiency through the core		X	X	X	—[c]	X		—[d]	—[e]	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of jet pump inlet mixers or throats break, causing failure of some significant number of jet pumps, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, rerouting coolant flow, reducing coolant flow efficiency through the core		X								X —[f]	X
Jet Pump Diffuser and Adapter*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Jet pump diffuser and/or adapter breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	X	X	X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of jet pump diffusers and/or adapters break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, reducing coolant flow efficiency through the core		X	X	X	—[c]	X		—[d]	—[e]	X	X
Common Mode: Some significant number of jet pump diffusers and/or adapters break, causing failure of some significant number of jet pumps, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, rerouting coolant flow, reducing coolant flow efficiency through the core		X								X —[f]	X
Jet Pump Sensing Line*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of jet pump sensing lines break, rerouting minimal coolant flow	X	X	X	X	X	X	X	X	X	X	X
Standpipe											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head	X	X	X	X	X	X	X	X	X	X	X
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a feedwater sparger		X	—[c]	X	X	—[n]	X	—[g]	X —[h]	X	X
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of LPCS or one of the core spray lines		X	X	—[k,l]	X	X	X	X	X	X —[l]	X
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of HPCS		X	—[l]	X	X	X	X	X	X	X —[l]	X
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a single LPCI line located in the annulus		X	X	X	—[r]	X	X	X	X	X	X
Common Mode: Some significant number of standpipes break, allowing leakage of the steam coolant into the water filled area above the core shroud head	X	X	X	X	X		X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation									
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of standpipes break, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS) and LPCI lines located in the annulus		X			—[f]		X	—[g]	X —[h]	X —[i]	X
Steam Separator											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and closing off steam flow through that standpipe	X	X	X	X	X	X	X	X	X	X	X
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a feedwater sparger		X	—[c]	X	X	—[n]	X	—[g]	X —[h]	X	X
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the LPCS or one of the core spray lines		X	X	—[k,l]	X	X	X	X	X	X —[i]	X
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the HPCS		X	—[l]	X	X	X	X	X	X	X —[i]	X
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a single LPCI line located in the annulus		X	X	X	—[r]	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation									
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of steam separators break, allowing leakage of the steam coolant into the water filled area above the core shroud head		X	X	X	X	X	X	X	X	X	X
Common Mode: Some significant number of steam separators break, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS) and LPCI lines located in the annulus		X			—[f]		X	—[g]	X —[h]	X —[i]	X
Steam Dryer Assembly											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Steam dryer assembly breaks, displacing vertically and laterally and deforming the dryers, separators, and standpipes to completely eliminate the steam flow path	X	X	X	X	X	X	X	X	X	X	X
Head Spray*											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Surveillance Specimen Holder											
Parts break off and jam more than MANNF CRDs			X	X	X	X	X	X	X	X	X
Parts break off and block coolant flow in no more than MANBC pathways	X	X	X	X	X	X	X	X	X	X	X
Single surveillance holder breaks and impacts an access hole cover, allowing coolant leakage from lower plenum to annulus	X	X	X	X	X	X	X	X	X	X	X

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of surveillance holders break and impact all access hole covers, allowing coolant leakage from lower plenum to annulus	X	X	X	X	X	X	X	X	X	X	X

Table Notes:

Reactor vessel internals not considered for IGSCC failure in this table include neutron source holders.

Recirc – recirculation

* - Assumption made that this internal is not large enough to cause functional damage to any other internal when impact is considered, except that the core dP line can damage the SLC line and vice versa.

X - System is functional for mitigation purposes. Blank indicates system fails to function during normal operation.

MANNF - Maximum allowable number of control rods/control rod drives that can be inoperable per safety regulations before reactor scram is not achievable with most reactive fuel loading possible.

MANBC - Maximum allowable number of completely blocked coolant pathways before fuel damage is anticipated.

a. Coolant flow out of bottom RPV head may not carry SLC to core region. Only those plants with SLC injected through core spray or HPCS lines may benefit from SLC injection for this scenario.

b. SLC is available on those plants with SLC injection through core spray or HPCS lines.c. System is available on BWR/5s and 6s.

d. Only those plants with RCIC will have that system available.

Table A-3. (continued).

Reactor Vessel Internal Components Cascading Failure List	Systems Functional For Mitigation										
	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood

e. System is available on BWR/6s.

f. System is available on BWR/3s and 4s.

g. Only those plants with IC will have that system available.

h. System is not available on BWR/6s.

i. SLC is not available on those plants with SLC injection through core spray or HPCS lines.

j. System available for BWR/2s, 3s, and 4s.

k. For BWR/2s, 3s, and 4s, core spray reduced to half capacity.

l. System not available on BWR/5s and 6s.

m. Reduced spray effectiveness of spargers but coolant flow still able to enter inside core shroud.

n. System available but with reduced flow capacity.

o. System available but with reduced flow capacity on BWR/3s and 4s. Full capacity is available on BWR/5s and 6s.

p. Reduced dispersion but coolant flow still able to enter annulus.

q. System available but with reduced flow capacity on BWR/2s, 3s, 4s, and 5s.

r. System is available but with reduced flow capacity on BWR/5s and 6s.

Table A-4. Mitigation systems functional for use when a single or common mode IGSCC failure occurs during accident conditions with cascading effects.

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event										
		Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Floo d
In-Core Instrument Housing												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of in-core instrument housings break with loss of RPV pressure boundary significantly challenging coolant makeup capabilities and potentially lowering core reflood levels, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All*	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	None	all	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
In-Core Instrument Guide Tube												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One guide tube breaks, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One guide tube breaks, loss of associated instrumentation results, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One guide tube breaks, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of guide tubes break, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
IRM / SRM / LPRM Tube												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Floo d
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	Al	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One tube breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One tube breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One tube breaks, loss of RPV pressure boundary and associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of tubes break with loss of RPV pressure boundary challenging coolant makeup capabilities, loss of associated instrumentation results, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core dP Line												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Core dP line breaks, doesn't measure dP correctly and eliminates functionality of SLC line	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None*	All
Core dP line breaks and eliminates functionality of SLC line, doesn't measure dP correctly, and parts jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None*	All
Core dP line breaks and eliminates functionality of SLC line, doesn't measure dP correctly, and parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None*	All
Core dP line breaks and eliminates functionality of SLC line, doesn't measure dP correctly, parts jam more than MANNF CRDs, and parts block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None*	All
SLC Line												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
SLC line breaks and does not disperse SLC as intended but is still injected	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
SLC line breaks and eliminates functionality of core dP line	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event										
		Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
SLC line breaks, cannot inject SLC, and eliminates functionality of core dP line	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None*	All
SLC line breaks, cannot inject SLC, eliminates functionality of core dP line, and parts jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None[2]	All
SLC line breaks, cannot inject SLC, eliminates functionality of core dP line and parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None[2]	All
SLC line breaks, cannot inject SLC, eliminates functionality of core dP line, parts jam more than MANNF CRDs, and parts block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None*	All
CRD Blade												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One control rod blade deforms, jams that CRD and blocks coolant flow	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One control rod blade deforms, jams that CRD and blocks coolant flow and other parts break off and jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
One control rod blade deforms, jams that CRD and blocks coolant flow and other parts block coolant flow in no more than MANBC total pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One control rod blade deforms, jams that CRD and blocks coolant flow, other parts break off and jam more than MANNF other CRDs, and other parts block coolant flow in no more than MANBC total pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: More than MANNF control rod blades deform and their insertion or withdrawal is eliminated, and coolant flow is blocked in more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
CRD Housing												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks and does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks and does not support fuel support piece and fuel assembly and single control rod drops	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single CRD insertion or withdrawal results, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One housing breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Common Mode: Some significant number of CRD housings break with loss of RPV pressure boundary significantly challenging coolant makeup capabilities and potentially lowering core reflood levels, fuel support pieces and fuel assemblies are not properly supported, more than MANNF control rods drop and/or the loss of functionality of more than MANNF CRDs result, and coolant flow is blocked in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All*	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
CRD Guide Tube												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	none	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One guide tube breaks and does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One guide tube breaks and does not support fuel support piece and fuel assembly, loss of single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One guide tube breaks and does not support fuel support piece and fuel assembly, loss of single control rod insertion or withdrawal results, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One guide tube breaks and does not support fuel support piece and fuel assembly, loss of single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of guide tubes break and do not support fuel support pieces and fuel assemblies, loss of the functionality of more than MANNF CRDs result, and coolant flow is blocked in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
CRD Stub Tube												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD stub tube breaks and does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD stub tube breaks and does not support fuel support piece and fuel assembly and single control rod drops	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	all	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary and single control rod insertion or withdrawal results, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD stub tube breaks and does not support fuel support piece and fuel assembly, loss of RPV pressure boundary results, single control rod drops, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Common Mode: Some significant number of CRD stub tubes break with loss of RPV pressure boundary significantly challenging coolant makeup capabilities and potentially lowering core reflood levels, fuel support pieces and fuel assemblies are not properly supported, more than MANNF control rods drop and/or the loss of functionality of more than MANNF CRDs result, and loose parts block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All*	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
CRD Index Tube and Spud												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD index tube or spud breaks and single control rod cannot insert or withdraw	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD index tube or spud breaks and lets single control rod drop	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD index tube or spud breaks, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
One CRD index tube or spud breaks, single control rod drops, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD index tube or spud breaks, single control rod cannot insert or withdraw, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD index tube or spud breaks, single control rod drops, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD index tube or spud breaks, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One CRD index tube or spud breaks, single control rod drops, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of CRD index tubes or spuds break, more than MANNF control rods drop and/or the loss of functionality results, and loose parts block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
CRD Thermal Sleeve												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One thermal sleeve breaks and single control rod cannot insert or withdraw	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly and prevents single control rod insertion or withdrawal	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly, single control rod cannot insert or withdraw, and loose parts block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One thermal sleeve breaks and guide tube does not support fuel support piece and fuel assembly, single control rod cannot insert or withdraw, and loose parts jam more than MANNF other CRDs and block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of thermal sleeves break and guide tubes do not support fuel support pieces and fuel assemblies, more than MANNF control rods cannot insert or withdraw, and loose parts block coolant flow in no more than MANBC pathways	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Fuel Support												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
One fuel support breaks which does not support the adjacent fuel assemblies, prevents single control rod insertion or withdrawal, and coolant flow is blocked in that one location	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of fuel supports break displacing the fuel assemblies, some significant number of control rods cannot insert or withdraw, and coolant flow is blocked around fuel assemblies	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core Shroud Support												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core shroud support breaks, allowing coolant leakage to flow from lower plenum to annulus and lowering core reflood level after a RLB	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Core shroud support breaks, displacing the core shroud, core plate, nuclear core, top guide, core shroud head, steam separators, steam dryers, and other internals attached to the core shroud support or core shroud, blocking coolant flow, eliminating the functionality of some significant number of control rods, jet pumps, feedwater spargers, SLC, core spray (including LPCS and HPCS) and LPCI lines which penetrate the core shroud and lowering the core reflood level after a RLB	2	None	None	None	None	N/A	None	None	None	None	None	All
	3	None	None	None	None	None	None	None	None	None	None	All
	4	None	None	None	None	None	None	None	None	None	None	All
	5	None	None	None	None	None	None	None	None	None	None	All
	6	None	None	None	None	None	None	None	None	None	None	All
Access Hole Cover												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Access hole cover breaks and allows coolant leakage from lower plenum to annulus, lowering core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: All access hole covers break and allow coolant leakage from lower plenum to annulus, and lowering core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core Plate												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core plate breaks and tilts or partially displaces the nuclear core, eliminating the functionality of some significant number of control rods and creating coolant flow blockage	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core plate breaks off from core shroud support ledge, displacing the nuclear core, creating coolant flow blockage, and eliminating the functionality of SLC and some significant number of control rods	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	None*	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	None*	All
Core Shroud												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core shroud breaks allowing coolant leakage from inside shroud to annulus, lowering core reflood level after a RLB	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core shroud breaks and displaces, deforming the core, blocking coolant flow, and eliminating the functionality of some significant number of control rods	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Core shroud breaks and displaces, deforming the core, blocking coolant flow, and eliminating the functionality of some significant number of control rods and jet pumps, and lowering core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	None	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	None	All	All	All	H	None	D,H,K	None	All	All
	6	None	None	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All
Core shroud breaks, displacing vertically and laterally deforming the core, preventing control rod insertion or withdrawal, eliminating the functionality of feedwater spargers, SLC, core spray (including LPCS and HPCS) and LPCI lines which penetrate the core shroud and blocking coolant flow	2	None	None	None	None	N/A	None	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	None	All
	3	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	All
	4	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	All
	5	None	None	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	All
	6	None	None	None	None	None	None	A,B,D,E,F,H,K	None	None	None	All
Core shroud breaks, displacing vertically and laterally, deforming the core, preventing control rod insertion or withdrawal, eliminating the functionality of jet pumps, feedwater spargers, SLC, core spray (including LPCS and HPCS) and LPCI lines which penetrate the core shroud, lowering core reflood level after a RLB and blocking coolant flow	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	None	None	None	None	None	None	None	None	All
	4	None	None	None	None	None	None	None	None	None	None	All
	5	None	None	None	None	None	None	None	None	None	None	All
	6	None	None	None	None	None	None	None	None	None	None	All
Core Shroud Head												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Floo d
Core shroud head breaks, displacing vertically and laterally, allowing coolant leakage from inside shroud to annulus, and deforming the standpipes and steam separators to significantly reduce that steam coolant flow path	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core shroud head breaks, displacing vertically and laterally, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation	2	None	All	None	None	N/A	None	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	5	None	All	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	6	None	All	None	None	None	None	A,B,D,E,F,H,K	None	None	All*	All
Core shroud head breaks, displacing vertically and laterally, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path	2	None	All	None	None	N/A	None	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	5	None	All	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	6	None	All	None	None	None	None	A,B,D,E,F,H,K	None	None	All*	All
Core Shroud Head Bolt												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Floo d
Common Mode: Some significant number of core shroud head bolts break, displacing core shroud head, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path	2	None	All	None	None	N/A	None	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	5	None	All	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	6	None	All	None	None	None	None	A,B,D,E,F,H,K	None	None	All*	All
Guide Rod												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: All guide rods break	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Top Guide or Grid												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event										
		Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Top guide breaks, displacing laterally and vertically deforming the fuel assemblies, blocking coolant flow, and eliminating the functionality of some significant number of control rods	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Top guide breaks, displacing laterally and vertically deforming the fuel assemblies, blocking coolant flow, and eliminating the functionality of some significant number of control rods and the functionality of core spray (including LPCS and HPCS) and LPCI lines inside the core shroud	2	None	None	None	None	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	None	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	None	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	None	None	None	None	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	None	None	None	None	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
Core Spray or LPCS Annulus Pipe*												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Core spray line breaks, reducing flow of core spray system inside core shroud by half or eliminating LPCS flow inside core shroud	2	None	All	None	4	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	4	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	4	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	All	All	None	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	None	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud	2	None	All	None	None	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	None	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	None	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud, and eliminating functionality of feedwater spargers	2	None	All	None	None	N/A	None	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud, eliminating the functionality of jet pumps, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	None	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	None	None	H	None	D,H,K	None	All	All
	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Common Mode: Excluding single LPCS, both core spray lines break, eliminating flow of core spray inside core shroud, eliminating the functionality of feedwater spargers and jet pumps, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	None	None	None	None	None	None	All	All
	4	None	All	None	None	None	None	None	None	None	All	All
	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Core Spray or LPCS Inside Shroud (Sparger)*												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single core spray [or LPCS sparger] breaks, reducing effectiveness of that ECC core spray pattern, and impacting the other core spray sparger [or HPCS sparger] and eliminating that ECC flow path	2	None	All	None	4,5	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	4,5	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	4,5	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	All	None	5	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	5	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
Single core spray [or LPCS sparger] breaks, reducing effectiveness of that ECC core spray pattern, impacting top guide, deforming a single control rod and a single fuel assembly, and blocking coolant flow at that location	2	None	All	None	5	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	5	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	5	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	5	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	5	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Excluding the LPCS sparger, both core spray spargers break reducing effectiveness of ECC core spray patterns but ECC still enters inside the core shroud	2	None	All	None	5	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	5	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	5	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Floo d
Common Mode: Excluding the LPCS sparger, both core spray spargers break, reducing the effectiveness of ECC core spray patterns but ECC still enters inside the core shroud and both core spray spargers impact the top guide, moving or deforming fuel assemblies, damaging more than MANNF control rods, and blocking coolant flow in no more than MANBC pathways	2	None	None	None	5	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	5	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	5	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
HPCS Annulus Pipe (BWR/5s and 6s)*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
HPCS line breaks, eliminating HPCS flow inside core shroud	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	None	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
HPCS Inside Shroud (Sparger) (BWR/5s and 6s)*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
HPCS sparger breaks, reducing effectiveness of ECC high pressure core spray patterns, and impacts the LPCS sparger, eliminating that ECC flow path	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	5	None	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	5	None	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
HPCS sparger breaks, reducing effectiveness of ECC high pressure core spray patterns, impacting top guide and deforming a single control rod and a single fuel assembly, blocking coolant flow at that location	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	5	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	5	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Both LPCS and HPCS spargers break, reducing effectiveness of both ECC core spray patterns but ECC still enters inside the core shroud and both LPCS and HPCS spargers impact the top guide, moving or deforming fuel assemblies, damaging more than MANNF control rods, and blocking coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	5	5	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	5	5	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
LPCI Coupling (BWR/5s and 6s)*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single LPCI coupling breaks, reducing LPCI flow inside core shroud	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	6	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	6	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of LPCI couplings break, eliminating LPCI flow inside core shroud	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	None	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	None	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of LPCI couplings break, impacting some significant number of jet pumps and eliminating their functionality, allowing coolant leakage into annulus, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	None	H	None	D,H,K	None	All	All
	6	None	All	All	All	None	H	None	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of LPCI couplings break, impacting some significant number of the feedwater spargers, eliminating their functionality and allowing coolant leakage into annulus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	None	None	A,B,D,E,F,H,K	None	None	All	All
Common Mode: Some significant number of LPCI couplings break, impacting LPCS, eliminating low pressure ECC spray into the core shroud and allowing coolant leakage into annulus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	None	None	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	None	None	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of LPCI couplings break, impacting HPCS, eliminating high pressure ECC spray into the core shroud and allowing coolant leakage into annulus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	None	All	None	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	All	None	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
Common Mode: Some significant number of LPCI couplings break, impacting the core shroud head bolts and displacing the core shroud head, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of feedwater spargers, LPCS, and HPCS lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	6	None	All	None	None	None	None	A,B,D,E,F,H,K	None	None	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
LPCI Baffle (BWR/5s) or Flow Diverter (BWR/6s)*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single LPCI baffle breaks, eliminating in-core instrumentation and impacts top guide, deforming a single control rod and a single fuel assembly, blocking coolant flow at that location	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single LPCI flow diverter breaks, eliminating in-core instrumentation and flow diverter impacts, moves, and deforms adjacent fuel assemblies, deforms more than MANNF control rods, and blocks coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of LPCI baffles break, eliminating in-core instrumentation and baffles impact top guide, moving or deforming adjacent fuel assemblies, deforming more than MANNF control rods, and blocking coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of LPCI flow diverters break, eliminating in-core instrumentation and flow diverters impact and deform adjacent fuel assemblies, deforming more than MANNF control rods, and blocking coolant flow in more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Feedwater Sparger*												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	Al
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Sparger breaks off and impacts some significant number of the jet pumps, reducing their flow functionality, allowing coolant leakage into annulus, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K[7]	All	A,B,D,E,F,H,K[6]	A,C,H[7]	A,B,D,E,F,H,K[6]	D,H,K[7]	A,B,D,E,F,H,K[6]	All	All
	4	None	All	D,H,K[7]	All	A,B,D,E,F,H,K[6]	H[7]	A,B,D,E,F,H,K[6]	D,H,K[7]	A,B,D,E,F,H,K[6]	All	All
	5	None	All	All	All	All	H[7]	A,B,D,E,F,H,K[6]	D,H,K[7]	A,B,D,E,F,H,K[6]	All	All
	6	None	All	All	All	All	H[7]	A,B,D,E,F,H,K[6]	D,H,K[7]	A,C,D,E,G,H,K	All	All
Sparger breaks off and impacts adjacent standpipes, reducing their flow functionality and allowing coolant leakage to water-filled outside region	2	None	All	None	All	N/A	A,C,H[7]	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K[7]	All	A,B,D,E,F,H,K	A,C,H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K[7]	All	A,B,D,E,F,H,K	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,C,D,E,G,H,K	All	All
Sparger breaks off, impacting adjacent core shroud head bolts, and displacing or perforating the core shroud head such that leakage from inside the core shroud to the annulus occurs	2	None	All	None	All	N/A	A,C,H[7]	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K[7]	All	A,B,D,E,F,H,K	A,C,H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K[7]	All	A,B,D,E,F,H,K	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,C,D,E,G,H,K	All	All
Sparger breaks off and impacts the steam dryer assembly, reducing its functionality and breaking the dryer seal skirt	2	None	All	None	All	N/A	A,C,H[7]	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K[7]	All	A,B,D,E,F,H,K	A,C,H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K[7]	All	A,B,D,E,F,H,K	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H[7]	A,B,D,E,F,H,K	D,H,K[7]	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of the feedwater spargers break, impacting the remaining feedwater spargers, eliminating their functionality	2	None	All	None	All	N/A	A,C,H[6,7]	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	None	All	A,B,D,E,F,H,K	A,C,H[6,7]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	All	A,B,D,E,F,H,K	H[6,7]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H[6,7]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H[6,7]	A,B,D,E,F,H,K	None	None	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Floo d
Common Mode: Some significant number of feedwater spargers break, impacting some significant number of jet pumps and eliminating their functionality, allowing coolant leakage into annulus, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K[7]	All	None	A,C,H[7]	None	D,H,K	None	All	All
	4	None	All	D,H,K[7]	All	None	H[7]	None	D,H,K	None	All	All
	5	None	All	All	All	All	H[7]	None	D,H,K	None	All	All
	6	None	All	All	All	All	H[7]	None	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of feedwater spargers break, impacting some significant number of the LPCI couplings, eliminating low pressure ECC flooding into the core shroud and allowing coolant leakage into annulus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	None	H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	None	H*	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of feedwater spargers break, impacting both core spray lines or LPCS, eliminating low pressure ECC spray into the core shroud and allowing coolant leakage into annulus	2	None	All	None	None	N/A	A,C,H*	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K[7]	None	A,B,D,E,F,H,K	A,C,H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K[7]	None	A,B,D,E,F,H,K	H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	All	All	None	All	H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	None	All	H*	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of feedwater spargers break, impacting HPCS, eliminating high pressure ECC spray into the core shroud and allowing coolant leakage into annulus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	None	All	All	H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	All	All	H*	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
Common Mode: Some significant number of feedwater spargers break, impacting the core shroud head bolts and displacing the core shroud head, allowing coolant leakage from inside shroud to annulus, eliminating the functionality of core spray (including LPCS and HPCS), and LPCI lines which enter the reactor vessel near the core shroud head elevation, and deforming the standpipes and steam separators sufficiently to significantly reduce that steam coolant flow path	2	None	All	None	None	N/A	A,C,H*	A,B,D,E,F,H,K	A,B,D,E,F,H,	A,B,D,E,F,H,K	All*	All
	3	None	All	D,H,K[7]	None	A,B,D,E,F,H,K	A,C,H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	4	None	All	D,H,K[7]	None	A,B,D,E,F,H,K	H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	All	None	None	None	H*	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	None	None	H*	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Jet Pump Inlet Riser*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump inlet riser breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump inlet risers break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	All	All	All	All	H	None	D,H,K	None	All	All
	6	None	All	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump inlet risers break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	None	None	None	None	None	None	All*	All
	4	None	All	None	None	None	None	None	None	None	All*	All
	5	None	All	None	None	None	None	None	None	None	All*	All
	6	None	All	None	None	None	None	None	None	None	All*	All
Jet Pump Riser Brace and Wedge and Restrainer*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump riser brace or wedge and restrainer breaks and leads to failure of that jet pump	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump riser braces and wedges and restrainers break, causing some significant number of inlet risers to break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	All	All	All	All	H	None	D,H,K	None	All	All
	6	None	All	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump riser braces and wedges and restrainers break, causing some significant number of inlet risers to break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	None	None	None	None	None	None	All*	All
	4	None	All	None	None	None	None	None	None	None	All*	All
	5	None	All	None	None	None	None	None	None	None	All*	All
	6	None	All	None	None	None	None	None	None	None	All*	All
Jet Pump Hold-Down Beam*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, permitting the entire "ram's head" to displace, eliminating the functionality of a feedwater sparger located in the annulus, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	All	A,B,D,E,F,H,K	A,C,H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	All	A,B,D,E,F,H,K	H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H[6]	A,B,D,E,F,H,K	None	None	All	All
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, permitting the entire "ram's head" to displace, eliminating the functionality of core spray (including LPCS and HPCS) lines located in the annulus, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	None	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	4	None	All	D,H,K	None	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	All	None	None	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	None	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
Jet pump hold-down beam breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, permitting the entire "ram's head" to displace, eliminating the functionality of the LPCI lines located in the annulus, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	None	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	None	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump hold-down beams break, causing the associated "ram's heads" to break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	All	All	All	All	H	None	D,H,K	None	All	All
	6	None	All	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Common Mode: Some significant number of jet pump hold-down beams break, causing the associated "ram's heads" to break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps, and rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	None	None	None	None	None	None	All*	All
	4	None	All	None	None	None	None	None	None	None	All*	All
	5	None	All	None	None	None	None	None	None	None	All*	All
	6	None	All	None	None	None	None	None	None	None	All*	All
Jet Pump Transition Piece*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump transition piece breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump transition pieces break, causing the associated "ram's heads" to break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	All	All	All	All	H	None	D,H,K	None	All	All
	6	None	All	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Common Mode: Some significant number of jet pump transition pieces break, causing the associated "ram's heads" to break, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	None	None	None	None	None	None	All*	All
	4	None	All	None	None	None	None	None	None	None	All*	All
	5	None	All	None	None	None	None	None	None	None	All*	All
	6	None	All	None	None	None	None	None	None	None	All*	All
Jet Pump Inlet Elbow*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump inlet elbow breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump inlet elbows break, rerouting coolant flow, and eliminating the functionality of some significant number of jet pumps	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	All	All	All	All	H	None	D,H,K	None	All	All
	6	None	All	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All
Jet Pump Nozzle*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Floo d
		Systems Functional For Mitigation Per Significant Initiating Event										
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, and loose parts jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow, reducing coolant flow efficiency through the core, and loose parts block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump nozzle breaks, causing failure of that jet pump, rerouting coolant flow, reducing coolant flow efficiency through the core, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump nozzles break, causing failure of some significant number of jet pumps, rerouting coolant flow, reducing coolant flow efficiency through the core, and loose parts jam more than MANNF CRDs and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	None	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	None	All	All	All	H	None	D,H,K	None	All	All
	6	None	None	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event										
		Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Jet Pump Inlet Mixer or Throat*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump inlet mixer or throat breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump inlet mixers or throats break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, reducing coolant flow efficiency through the core, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	All	All	All	All	H	None	D,H,K	None	All	All
	6	None	All	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump inlet mixers or throats break, causing failure of some significant number of jet pumps, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, rerouting coolant flow, reducing coolant flow efficiency through the core, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	None	None	None	None	None	None	All*	All
	4	None	All	None	None	None	None	None	None	None	All*	All
	5	None	All	None	None	None	None	None	None	None	All*	All
	6	None	All	None	None	None	None	None	None	None	All*	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Jet Pump Diffuser and Adapter*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Jet pump diffuser and/or adapter breaks, causing failure of that jet pump, rerouting coolant flow and reducing coolant flow efficiency through the core, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump diffusers and/or adapters break, eliminating the functionality of some significant number of jet pumps, rerouting coolant flow, reducing coolant flow efficiency through the core, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	None	A,C,H	None	D,H,K	None	All	All
	4	None	All	D,H,K	All	None	H	None	D,H,K	None	All	All
	5	None	All	All	All	All	H	None	D,H,K	None	All	All
	6	None	All	All	All	All	H	None	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump diffusers and/or adapters break, causing failure of some significant number of jet pumps, impacting and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS), and LPCI lines, rerouting coolant flow, reducing coolant flow efficiency through the core, and lowering the core reflood level after a RLB	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	None	None	None	None	None	None	None	All*	All
	4	None	All	None	None	None	None	None	None	None	All*	All
	5	None	All	None	None	None	None	None	None	None	All*	All
	6	None	All	None	None	None	None	None	None	None	All*	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Jet Pump Sensing Line*												
Parts break off and jam more than MANNF CRDs	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of jet pump sensing lines break, rerouting minimal coolant flow	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Standpipe												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a feedwater sparger	2	None	All	None	All	N/A	A,C,H[6]	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	None	All	A,B,D,E,F,H,K	A,C,H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	All	A,B,D,E,F,H,K	H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H[6]	A,B,D,E,F,H,K	None	None	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
		Systems Functional For Mitigation Per Significant Initiating Event										
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of LPCS or one of the core spray lines	2	None	All	None	4	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All*	All
	3	None	All	D,H,K	4	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	4	None	All	D,H,K	4	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	All	All	None	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	None	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of HPCS	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	None	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
Single standpipe breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a single LPCI line located in the annulus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	6	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	6	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of standpipes break, allowing leakage of the steam coolant into the water filled area above the core shroud head	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of standpipes break, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS) and LPCI lines located in the annulus	2	None	All	None	None	N/A	None	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All*	All
	3	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	4	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	5	None	All	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	6	None	All	None	None	None	None	A,B,D,E,F,H,K	None	None	All*	All
Steam Separator												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event										
		Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and closing off steam flow through that standpipe	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a feedwater sparger	2	None	All	None	All	N/A	A,C,H[6]	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	None	All	A,B,D,E,F,H,K	A,C,H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	4	None	All	None	All	A,B,D,E,F,H,K	H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H[6]	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H[6]	A,B,D,E,F,H,K	None	None	All	All
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the LPCS or one of the core spray lines	2	None	All	None	4	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All*	All
	3	None	All	D,H,K	4	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	4	None	All	D,H,K	4	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	5	None	All	All	None	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	None	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the HPCS	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	None	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All*	All
	6	None	All	None	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All*	All
Single steam separator breaks, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of a single LPCI line located in the annulus	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	5	None	All	All	All	6	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	6	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of steam separators break, allowing leakage of the steam coolant into the water filled area above the core shroud head	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of steam separators break, allowing leakage of the steam coolant into the water filled area above the core shroud head and eliminating the functionality of the feedwater spargers, core spray (including LPCS and HPCS) and LPCI lines located in the annulus	2	None	All	None	None	N/A	None	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All*	All
	3	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	4	None	All	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	5	None	All	None	None	None	None	A,B,D,E,F,H,K	None	A,B,D,E,F,H,K	All*	All
	6	None	All	None	None	None	None	A,B,D,E,F,H,K	None	None	All*	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Steam Dryer Assembly												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Steam dryer assembly breaks, displacing vertically and laterally and deforming the dryers, separators, and standpipes to completely eliminate the steam flow path	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Head Spray*												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Surveillance Specimen Holder												
Parts break off and jam more than MANNF CRDs	2	None	None	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	None	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	None	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	None	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Parts break off and block coolant flow in no more than MANBC pathways	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table A-4. (continued).

Reactor Vessel Internal Components Cascading Failure List	BWR	Systems Functional For Mitigation Per Significant Initiating Event: Normal Shutdown	Scram	High Pressure ECC	ECC Low Pressure Spray	ECC Low Pressure Flooding	FW	Recirc	IC or RCIC	RHR or Shutdown Cooling	SLC	Core Flood
Single surveillance holder breaks and impacts an access hole cover, allowing coolant leakage from lower plenum to annulus and lowering core reflood level after a RLB to the recirculation outlet elevation	2	None	All	None	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All
Common Mode: Some significant number of surveillance holders break and impact all access hole covers, allowing coolant leakage from lower plenum to annulus and lowering core reflood level after a RLB to the recirculation outlet elevation	2	None	All	none	All	N/A	A,C,H	A,B,D,E,F,H,K	A,B,D,E,F,H,K	A,B,D,E,F,H,K	All	All
	3	None	All	D,H,K	All	A,B,D,E,F,H,K	A,C,H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	4	None	All	D,H,K	All	A,B,D,E,F,H,K	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	5	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,B,D,E,F,H,K	All	All
	6	None	All	All	All	All	H	A,B,D,E,F,H,K	D,H,K	A,C,D,E,G,H,K	All	All

Table Notes:

Reactor vessel internals not considered for IGSCC failure in this table neutron source holders.

Recirc – recirculation

* - Assumption made that this specific internal is not large enough to cause functional damage to any other internal when impact is considered. However, failure of this internal component could lead to the displacement of a larger internal which could impact and damage other internals, The exception is that the core dP line can damage the SLC line and vice versa.

None - Indicated system is not functional for any of the initiating events

N/A - Indicated component or system is not applicable to this BWR design

All - Indicated system is functional for all of the initiating events

Systems available per initiating event:

A-MSLB B-FWLB C-RLB D-SSE (during operation) E-MSLB + SSE F- FWLB + SSE G-RLB + SSE H-ATWS K-SSE (during refueling)

MANNF - Maximum allowable number of control rods/control rod drives that can be inoperable per safety regulations before reactor scram is not achievable with most reactive fuel loading possible.

MANBC - Maximum allowable number of completely blocked coolant pathways before fuel damage is anticipated.

1. Coolant flow out of bottom RPV head may not carry SLC to core region. Only those plants with SLC injected through core spray or HPCS lines may benefit from SLC injection for this scenario.

2. SLC is available on those plants with SLC injection through core spray or HPCS lines.

3. SLC is not available on those plants with SLC injection through core spray or HPCS lines.

4. For BWR/2s, 3s, and 4s, core spray reduced to half capacity.

5. Reduced spray effectiveness of spargers but coolant flow still able to enter inside core shroud.

6. System available but with reduced flow capacity.

7. Reduced dispersion but coolant flow still able to enter annulus.

Appendix B

Letter Report From R. W. Staehle and G. S. Was

Crack Growth Rate Analysis for 304 Stainless Steel

R. W. Staehle and G. S. Was

September 14, 1998

Objective: To recommend a best-estimate and 95% upper bound growth rate for IGSCC crack growth for 304 stainless steel under the following conditions:

a. 288°C
b. 0.1 μS/cm conductivity
c. ex-core operation (0-100 mV ECP)
d. R=0.95
e. weld sensitization (30 C/cm^2)
f. K = 30 ksi/in [33 MPa/m] (or growth rate as a function of K)
g. Assume cold work, if recommended

Identification of data for basis of recommendation:

As discussed in the meeting on July 17, 1998, there are two databases that contain crack growth data on 304 stainless steel under conditions which are relevant to our objective. They are the VIP database and the ABB databases. The VIP database is that described in Appendix C of EPRI TR-105873 (BWRVIP-14) [1] and is referred to as the model development database. The ABB database is that given in ref. [2] and is referred to as NWC condition in that reference. The databases are characterized as follows:

Item	VIP	ABB
No. data pts	122 (108 w/o runouts)	59 (43 w/o runouts)
Temp. (°C)	210 – 289	288
Cond. (μS/cm)	0.05 – 1.50	0.055 – 0.20
O_2 (ppb)	5 – 8000*	100 - 600
E_{corr} (mV_{SHE})	-575 to +250	-70 to +230
Mat'l cond.	1.4 – 32.3 C/cm^2	cold-worked
K (MPa/m)	11 – 60	11 - 60
R (K_{min}/K_{max})	0.25 – 1.0*	>0.9

Frequency (Hz)	$2.0 \times 10^{-4} - 0.1$*	$<2.4 \times 10^{-4}$

*Refers to master database described in BWRVIP-14. These values were not provided in Appendix C describing the 122 entry database.

Comparing these databases to the objectives of this project reveals that 1) the variables in the VIP database encompass a considerably wider range of applicability than do those in the ABB database, and 2) the variable ranges of the ABB database are a better match to the objectives than are the variable ranges of the VIP database. For this reason, we selected the ABB database on which to make best estimate and 95% upper bound estimates of crack growth rate.

This database consists of some 59 data points (measured crack growth rates), only 43 of which were measurable (the other 16 yielded values below the resolution of the instrumentation, and thus were denoted "runouts"). Hence, we selected the dataset consisting of only those samples which yielded measurable values of crack growth rate and denoted this set ABB (w/o runouts).

Crack growth rate is plotted against K for the 43 data points (open circles in red) in the database in the Figure. A least-squares fit to the data yields a crack growth rate (in green) of the form:

$da/dt = 1.386 \times 10^{-8} + 2.101 \times 10^{-9} \log(K)$. Inspection of the graph in the Figure reveals no discernable dependence of da/dt on K. In fact, the crack growth rate varies by only 10% over the range $10<K<60$ MPa/m, confirming what is evident from inspection.

The mean value of the log of the crack growth rate for the database is $\log(da/dt)_{mean} = -8.237$ or 5.8×10^{-9} mm/s. The value of 2σ is 1.526. Therefore, the 95% upper bound crack growth rate (mean + 2σ)is $da/dt\,|_{mean+2\sigma} = 1.95 \times 10^{-7}$ mm/s ($\log(da/dt\,|_{mean+2\sigma}) = -6.711$). The mean and the 95% upper bound values are plotted as dashed (black) lines over the data, and the area in between the lines is cross-hatched in blue. Note that since the database extends from 10 to 60 MPa/m, this is the K range of applicability of the mean and the 95% upper bound crack growth rates. Also note that the mean accurately captures the observed crack growth rates and the upper bound value lies just above the highest crack growth rates measured.

These crack growth rate values can be compared to those given by the MD01 Rev 2.1 model of the ABB data [1], the NRC disposition line [3] and the BWRVIP-14 correlation [2] in the 25-35 MPa/m (22-32 ksi/in) regime. The MD01 Rev. 2.1 correlation is plotted as a black line that plateaus at a value of about 5.5×10^{-7} mm/s. The NUREG 0313 Rev. 2 correlation is the orange line that intersects the 1×10^{-6} growth rate line just above 50 MPa/m. The VIP value of 1.55 x 10-7 mm/s is given as the horizontal blue line between 25 and 35 MPa/m.

As is evident from the plots, the three correlations and the 95% upper bound value of crack growth rate all fall within the narrow crack growth rate range 1.55 x 10^{-7} mm/s to 3.7 x 10^{-7} mm/s at a stress intensity, K of 30 ksi/in (33 MPa/m).

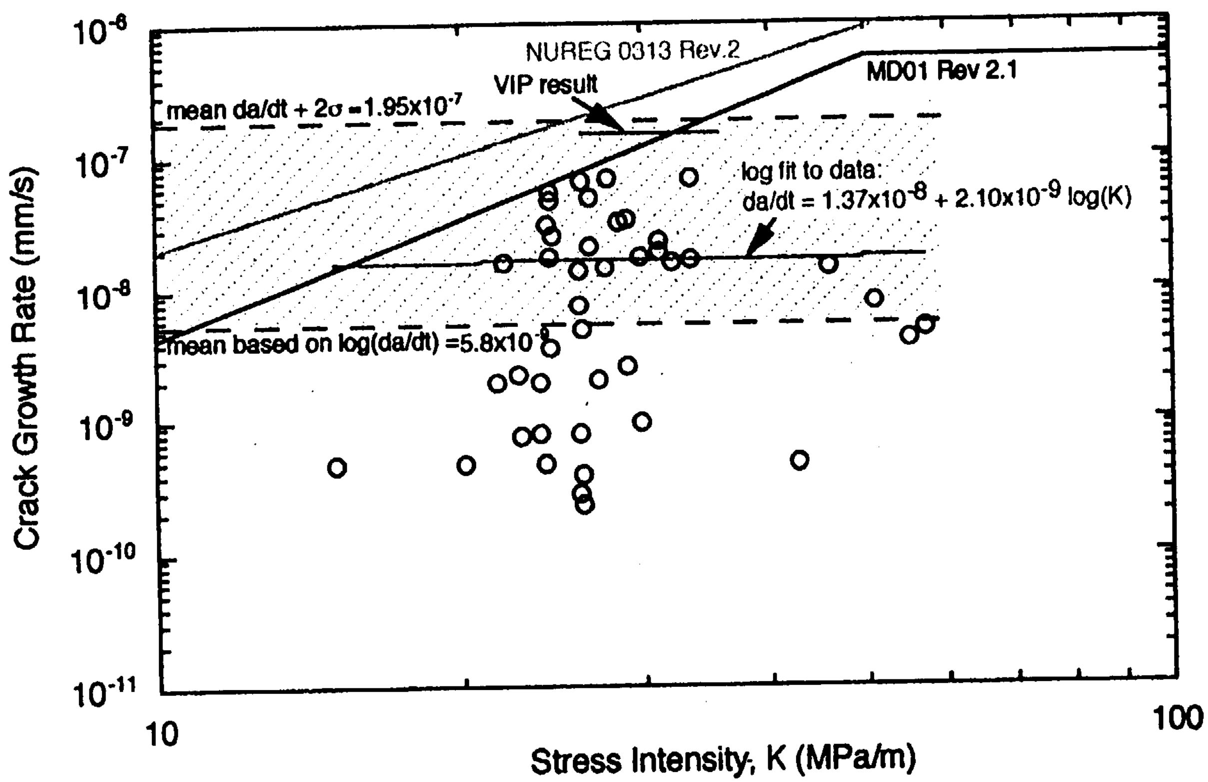
References:

1. BWR Vessel and Internals Project: Evaluation of Crack Growth in BWR Stainless Steel RPV Internals (BWRVIP-14), Electric Power Research Institute, Palo Alto, CA, EPRI TR-105873.

2. C. Jansson and U Morin, "Assessment of Crack Growth Rates in Austenitic Stainless Steels in Operating BWRs," 8th International Symposium on Environmental Degradation of Materials In Nuclear Reactor Systems – Water Reactors, National Association of Corrosion Engineers, Houston, TX., 1997, p. 667

3. W. S. Hazelton and W. H. Koo, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping," U.S. Nuclear Regulatory Commission Report NUREG 0313, Rev. 2, January, 1982.

Crack growth rate vs. K for ABB data (run-outs not included)



Crack growth rate vs stress intensity for ABB data from ref. 1, and several fits: NUREG 0313 Rev. 2, MD01 Rev. 2.1, VIP result, mean and mean + 2σ, and a least squares fit to the log of the data.

Appendix C

Letter Report From R. P. Kennedy (August 1998)

Suggested Upgrading of NUREG-1150
Seismic Risk Assessment of
For Use in Intergranular Stress Corrosion Cracking
Risk Assessment

by

Robert P. Kennedy
August 1998

1. Introduction

The only complete set of seismic fragilities of which I am aware for were those developed for the NUREG-1150 seismic probabilistic risk assessment (SPRA) of as documented in NUREG/CR-4550 (Ref. 1). However, this SPRA contains several deficiencies which should be addressed prior to use in the intergranular stress corrosion cracking risk assessment.

First, the 1988 LLNL seismic hazard estimates used in the 1150 SPRA as documented in Ref. 1 has exceedingly high mean annual frequencies of exceeding ground motion levels in excess of 0.10 g which results in excessively high estimates of the seismic induced core damage frequencies. This deficiency can be corrected by using the 1993 LLNL seismic hazard estimates for as documented in Ref. 2.

Secondly, the ground motion response spectrum shape shown in Figure 4.4 of Ref. 1 (reproduced herein as Figure 1) which was used to develop the response multiplication factors M_R of Ref. 1 is not compatible with the LLNL93 Uniform Hazard Response Spectrum (UHRS) shape defined in Ref. 2 for . Nor was the Figure 4.4 shape compatible with either the LLNL88 or EPRI UHRS shapes. This deficiency is approximately corrected herein in Section 2 for the LLNL93 (Ref. 2) UHRS shape.

Third, none of the earlier SPRAs (including the 1150 SPRA of) conducted a very thorough multi-man month seismic walkdown of the plant looking for situations such as inadequate or missing anchorage, seismic spatial interaction issues, or other issues which could significantly impact the seismic fragility of structures, systems, and components (SSCs) required to prevent core damage. Instead it was typically assumed that these issues did not exist and the plant satisfied all SAR commitments. However, subsequently it was

RPK ______________________________ Structural Mechanics Consulting
18971 Villa Terrace, Yorba Linda, CA 92886
714 777-2163 • 714 777-8299

$$A_{50} = \frac{2.0}{3.0} = 0.67g$$

$$\beta_R = \left[(0.26)^2 + (0.45)^2\right]^{1/2} = 0.52 \qquad (3)$$

$$\beta_U = \left[(0.35)^2 + (0.25)^2\right]^{1/2} = 0.43$$

The seismic risk is at least as much a function of the High-Confidence-Low Probability-of-Failure (HCLPF) capacity as it is of the median A_{50} capacity. This HCLPF capacity is define as the capacity corresponding to approximately 95% confidence of less than about 5% probability of failure and is computed from:

$$HCLPF = A_{50} \exp[-1.65(\beta_R + \beta_U)] \qquad (4)$$

and thus for the example inverter:

$$HCLPF = 0.14g \qquad (5)$$

Actually, it is very unlikely that this inverter has a HCLPF capacity as low as 0.14g since the plant's design SSE is 0.12g. Because of inherent design conservatism, the component HCLPF capacities are likely to be significantly greater than the design SSE. In fact, in the absence of the previously discussed unscreened issues, I would expect the lowest component HCLPF values to be at least 0.18g.

A likely fourth deficiency is that because generic fragilities were used, large logarithmic standard deviations β_R and β_U were typically specified in the Ref. 1 fragilities. As a result, component HCLPF values are likely to be artificially low and this will adversely affect the computed seismic risk estimates.

NUREG-1407 (Ref. 3) requested that perform a 0.3g Focused Scope seismic IPEEE review. If such a review had been performed, then would have defined the HCLPF capacity for each component with a HCLPF capacity less than 0.3g for all components in at least two success paths. If this Focused Scope seismic review had been performed, then situations such as the example inverter where Ref. 1 fragilities produce artificially low HCLPF values could have been identified and recommendations could have been made to reduce β values so as to produce realistic HCLPF values for these cases. Unfortunately, the seismic IPEEE review was a voluntary utility effort and the utility chose not to perform the requested 0.3g Focused Scope review which would have provided useful HCLPF information. Instead they performed a Reduced Scope review in Ref. 4 which only required them to review their SSCs for the 0.12g design SSE level. Thus, Ref. 4 is only marginally useful in establishing lower bound values on the Ref. 1 HCLPF capacities. Specific recommendations in this regard are given in Section 3.

2. Revised Response Factors

As noted previously, the Ref. 1 response factors M_R shown in Table 2 are based upon the ground response spectrum shape shown in Figure 1. However, the LLNL93 UHRS (Ref. 2) shape is considerably different. Appendix B of Ref. 2 provides spectral velocities S_V associated with a mean 1×10^{-4} annual exceedance frequency at several natural frequencies. These Ref. 2 values for are reproduced herein in Table 4. These spectral velocity S_V values are converted to spectral acceleration S_A values using:

$$S_A = \frac{S_V(2\pi f)}{980\text{cm/sec/g}} \tag{6}$$

where f is the natural frequency at which S_V and S_A are specified.

The mean 1×10^{-4} PGA for can be found to be 0.216g by interpolation of the PGA values listed in Appendix A of Ref. 2. Therefore, the 1×10^{-4} UHRS shape for can be defined by the ratios of S_A/PGA shown in Table 4 for various natural frequencies.

Table 5 compares the UHRS shape S_A/PGA values from Table 4 with the corresponding 1150 study values from Figure 1 to obtain a natural frequency f dependent ground motion scale factor SF_f from:

$$SF_f = \frac{\text{Table 4}(S_A/\text{PGA})}{\text{Figure 1}(S_A/\text{PGA})} \tag{7}$$

Note that at frequencies below 5 Hz, the SF becomes increasingly less than unity indicating that the 1150 Study ground motion has significantly more low frequency power than does the LLNL93 UHRS. At frequencies above 10 Hz, the SF becomes increasingly greater than unity indicating that the 1150 study ground motion has significantly more high frequency power than does the LLNL93 UHRS. However, in the important frequency range between 5 and 10 Hz, the SF is close to unity. These comparisons of Table 4 versus Figure 1 (S_A/PGA) ratios are then used as described below to modify the Ref. 1 response factors M_R shown in Table 2. The resulting revised M_R values are shown in Table 3.

The first 5 response factors shown in Table 2 are simply equal to the ground motion (S_A/PGA). Therefore, the revised Table 3 M_R factors for these first 5 items are simply equal to the Ref. 2 UHRS (S_A/PGA) ratios from Table 4 for the corresponding natural frequencies.

All of the remaining non-dummy response factors M_R (i.e., numbers 6 through 31)) represent structure modified response factors which are a function of the structure fundamental natural frequency f_s, the elevation in the structure at which the component is located, and the component fundamental natural frequency f_c. For these cases, above 2.5 Hz a revised response factor M_{RR} (Table 3) can be approximately estimated based on the original response factor M_{RO} using:

$$M_{RR} \approx 1 + (M_{RO} - 1)F_f \qquad (8)$$

where F_f is a frequency dependent correction factor given by:

$$F_f = \frac{AFN_f - 1}{AFO_f - 1} \qquad (9)$$

where:

AFN_f = LLNL93(Table 4) $(S_A/PGA)_f$
AFO_f = 1150 Study (Fig. 1) $(S_A/PGA)_f$

These F_f factors from Eqn. (9) are also given in Table 5 as a function of frequency f. The use of F_f values substantially different from unity is suspect and must be done with caution. For any case, judgement must be exercised in selecting the natural frequency at which F_f is to be obtained.

For cases where the component frequency f_c is greater than or approximately equal to the structure frequency f_s, the factor F_f should be estimated at the structure frequency f_s for components located above the approximate C.G. height within the structure. For components located on the base of the structure, the factor F_f should be estimated at the component frequency f_c. Interpolation between these two F_f values needs to be used for components located between the base and CG height in the structure.

For cases where $f_c \leq (f_s/2)$, the factor F_f should be based on the component frequency f_c. For cases where $(f_s/2) < f_c < f_s$, interpolation between F_f based on f_s and F_f based on f_c is required.

Table 6 presents my estimated F_f factors based upon the above guidance for the various structure response cases considered in Table 2. These F_f factors were then used in conjunction with the Table 2 M_{RO} factors to obtain the revised M_{RR} factors shown in Table 3 using Eqn. (8). Values in Table 3 were rounded off to the closest 0.05 where deemed appropriate. In most cases the revised M_R values from Table 3 are less than the original Table 2 values. However, there are two exceptions (cases 27 and 29) where the revised values exceed the original values. The revised values in Table 3 are shown handwritten whereas the original values are retained but crossed-through so that comparisons are easily made.

3. Use of IPEEE Study (Ref. 4) to Establish Lower Bound on HCLPF Capacity

The seismic IPEEE study (Ref. 4) can be used to establish that the SSE design response spectrum represents a lower bound on the HCLPF capacity for all SSCs reviewed in the seismic IPEEE study. With the following three exceptions, all fragility components given in Ref. 1 should have HCLPF capacities greater than this lower bound:

1. Loss of offsite power (defined as Component #1: Ceramic Insulators in Table 1 reproduced from Ref. 1). Offsite power was assumed to be lost in the seismic IPEEE and its capacity was not assessed.

2. Relay Chatter (Component #2). Relay Chatter capacities were not assessed in the Reduced Scope seismic IPEEE study.

3. Reactor Internals subject to significant intergranular stress corrosion cracking. The effect of significant intergranular stress corrosion cracking was not considered in either the seismic IPEEE Study (Ref. 4) or in the 1150 Study (Ref. 1).

The SSE design ground motion had a PGA value of 0.12g, but had a different response spectrum shape than the LLNL93 UHRS shape. Figure 3.1.1-2 of Ref. 4 shows the SSE design response spectrum. Table 7 compares this SSE spectrum shape with the LLNL93 UHRS shape. At least within the frequency range of 5 Hz to 15 Hz, the ratio SF_f between these two spectra shapes is close to unity. Because of the crudeness of estimating a lower bound on the HCLPF capacity as being equal to the design SSE, it does not appear to be warranted to make any adjustment for this small difference in spectral shapes.

Except for the three previously discussed exceptions, I recommend that no HCLPF capacity be allowed to fall below a PGA value of 0.12g which represents the SSE PGA value.

4 Summary of Recommendations

For the intergranular stress corrosion cracking risk assessment of , I recommend that the seismic fragilities given on page C1 of Ref. 1 (reproduced herein as Table 1) be used. However, the response factors given on page C2 of Ref. 2 should be revised to the values shown herein in Table 3 in order to be consistent with the LLNL 93 seismic hazard estimate (Ref. 2).

After the SSC fragilities have been defined in terms of the ground motion PGA through the use of Eqns. (1) and (2) which combines the fragility factors M_F, β_{FR}, and β_{FU} from Table 1 with the revised response factors M_R, β_{RR}, and β_{RU} from Table 3, the SSC HCLPF capacity should be computed from Eqn. (4). With the following three exceptions, no HCLPF value should be less than 0.12g:

1. Loss of Offsite Power (defined as Component #1: Ceramic Insulators in Table 1)

2. Relay Chatter (Component #2 in Table 1)

3. Reactor Internals subject to significant intergranular stress corrosion cracking

I don't believe that any of the other HCLPF values will come out below 0.12g when the fragility factors from Table 1 are combined with the revised response factors from Table 3. However, if it does come out below 0.12g, the β_R and β_U values should be appropriately reduced so as to bring the computed HCLPF capacity up to 0.12g.

With the use of these modified Ref. 1 fragilities, a note should be added to your report that it is assumed (without verification) that the unscreened seismic issues identified in Table 3.1.4-2 of Ref. 4 have either been or will be successfully resolved. Unless resolved, some of these issues are likely to significantly reduce the seismic capacities of some components below those defined by the modified Ref. 1 fragilities.

In order to obtain a realistic estimate of the core damage risk, I recommend that these modified Ref. 1 fragilities should be convolved with the LLNL93 (Ref. 2) PGA seismic hazard curve for as defined in Appendix A of Ref. 2. The older LLNL88 hazard curve which was used in Ref. 1 should no longer be used.

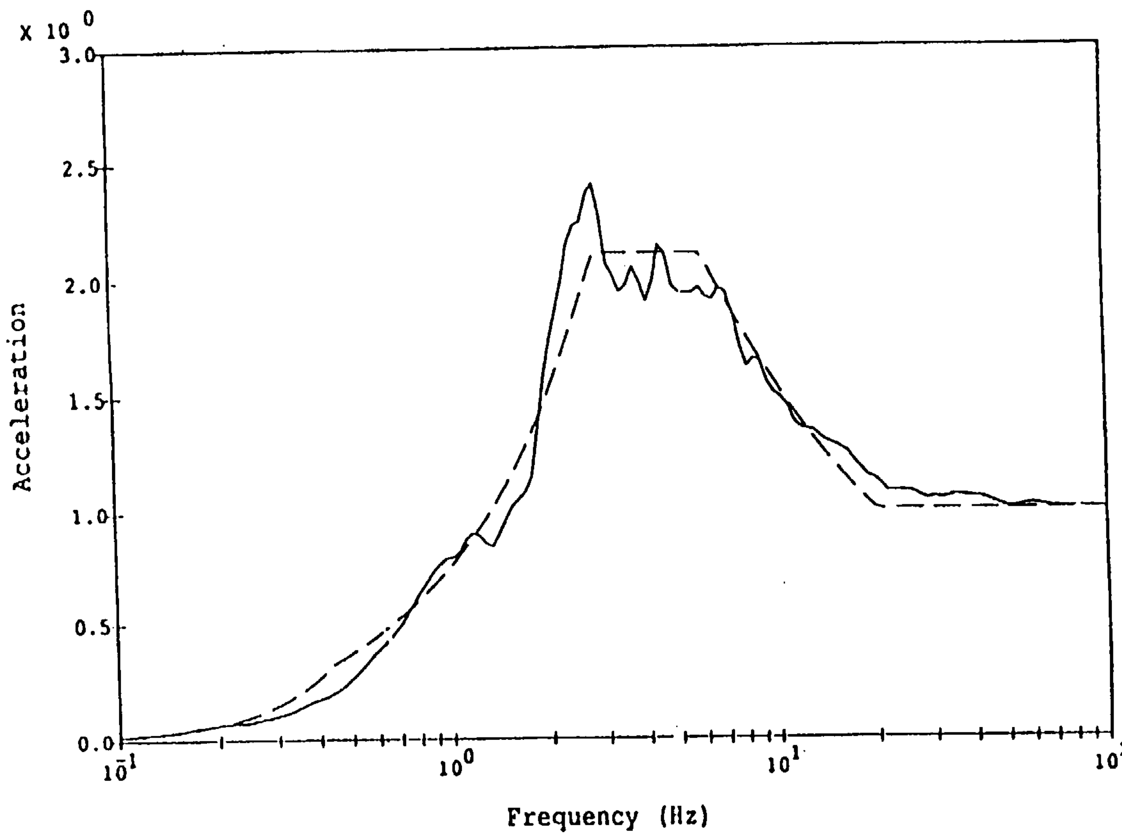
References

1. [Plant specific reference]

2. Sobel, P., *Revised Livermore Seismic Hazard Estimates for 69 Nuclear Power Plant Sites East of the Rocky Mountains*, NUREG-1488, US NRC, Oct. 1993

3. Chen, J.T., et.al., *Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities*, NUREG-1407, US NRC, June 1991

4. [Plant specific reference]



Legend:

Median of 10 Comp. ————

Rock 50% — — — —

Notes:

All spectra calculated at 5% damping

Acceleration in units of g

Figure 4.4 Power Station Median Free-Field Input Motion Compared to Median Rock Spectra from WASH-1255 (Ref. 12)

Figure 1: Reproduction of Figure 4.4 of Ref. 1

Table 1

FRAGILITIES FILE

No.	M_F	β_{fr}	β_{fu}	Category
1	0.25	0.25	.25	CERAMIC INSULATORS
2	4.00	0.48	.75	RELAY CHATTER
3	7.63	0.48	.74	CIRCUIT BREAKER TRIP
4	2.50	0.40	.39	BATTERIES
5	2.29	0.31	.39	BATTERY RACKS
6	2.00	0.26	.35	INVERTORS
7	8.80	0.28	.30	TRANSFORMERS
8	7.63	0.48	.74	MOTOR CONTROL CENTER
9	7.63	0.48	.66	AUX RELAY CABINET
10	6.43	0.29	.66	SWITCHGEAR
11	2.23	0.34	.19	CABLE TRAYS
12	11.50	0.46	.74	CONTROL PANELS AND RACKS
13	7.68	0.20	.35	LOCAL INSTRUMENTS
14	1.00	0.25	.31	DIESEL GENERATOR
15	12.10	0.27	.31	MOTORS-HORIZONTAL
16	2.80	0.25	.27	MOTOR-DRIVEN PUMPS & COMPRESSORS
17	2.21	0.22	.32	LG. VERT. M-D. CENTRIF PUMP
18	6.50	0.26	.60	LMOV
19	4.83	0.26	.60	SMALL MOV & AOVs
20	6.50	0.26	.34	LG. PNEUM/HYD VALVE
21	8.90	0.20	.35	LG. MANUAL, CHECK, RELIEF VALVE
22	12.50	0.33	.43	MISC. SMALL VALVES
23	3.00	0.30	.53	LG. HORIZ. VESSELS
24	1.84	0.25	.45	SM-MED HEAT EXCHANGERS & VESSELS
25	1.46	0.20	.35	LG. VERT VESSELS w/ FORMED HEADS
26	0.45	0.35	.29	LG. VERT. FLAT BOTTOMED TANKS
27	6.90	0.27	.31	AIR HANDLING UNITS
28	1.95	0.26	.28	BWR REACTOR SKIRT (GENERIC)
29	0.95892	0.50	.30	SLOCA FIT (SSMRP)
30	1.4967	0.4681	.30	MLOCA FIT (SSMRP)
31	1.26	0.35	.40	BWR RECIRC PUMP SUPPORT (GENERIC)
32	1.00	0.04	.17	DIKE AROUND CST AND RWST
33	0.55	0.11	.21	EMERGENCY COOLING TOWER (PEACH)
34	1.6	0.16	.27	REACTOR BLDG. SHEAR WALLS
35	1.2	0.10	.23	RADWASTE/TURBINE ROOF DIAPHRAGM
36	1.5	0.13	.25	RADWASTE/TURBINE SHEAR WALLS
37	0.50	0.11	.21	TURBINE BLDG.
38	1.5	0.13	.24	BLOCK WALLS-VARIOUS
39	99.0	0.3	.30	DUMMY EVENT-CAUSES NO SEISMIC FAILURE
40	0.01	0.3	.30	DUMMY EVENT-CAUSES FAILURE PF=1
41	3.30	0.15	.25	4KV BUSSES (PEACH BOTTOM)
42	0.95	0.15	.20	DG DAY TANKS
43	4.42	0.15	.25	HPCI ROOM COOLER

Table 2

RESPONSE MULTIPLE FILE

No.	M_r/pga	β_{rr}	β_{ru}	Response	
1	1.00	0.25	.25	FREE-FIELD	ZPA
2	2.08	0.45	.25		2-5 HZ
3	1.90	0.45	.25		5
4	1.78	0.35	.25		5-10
5	1.90	0.35	.25		7
6	1.20	0.35	.25	CS 135	ZPA
7	2.50	0.45	.25		5-10 HZ
8	1.40	0.35	.25	150	ZPA
9	3.00	0.45	.25		5-10
10	1.60	0.35	.25	165	ZPA
11	3.30	0.45	.25		5-10
12	1.00	0.35	.25	RB 91	ZPA
13	1.80	0.45	.25		5-10
14	1.80	0.45	.25		7
15	1.80	0.45	.25		5
16	1.10	0.35	.25	116	ZPA
17	2.10	0.45	.25		7
18	1.10	0.35	.25	135	ZPA
19	2.10	0.45	.25		7
20	1.30	0.35	.25	165	ZPA
21	3.00	0.45	.25		7
22	1.00	0.35	.25	DG 127	ZPA
23	1.80	0.45	.25		5-10
24	1.80	0.45	.25		5
25	1.00	0.35	.25	TB 116	ZPA
26	1.90	0.45	.25		7
27	1.30	0.35	.25	CWPS 114	ZPA
28	2.40	0.45	.25		7
29	1.40	0.35	.25	ECT 153	ZPA
30	2.60	0.45	.25		7
31	2.60	0.45	.25		5
32	1.00	0.00	.25	DUMMY RESPONSE FOR M & S LOCA	

Table 3 Revised

RESPONSE MULTIPLE FILE

No.	M_r/pga	β_{rr}	β_{ru}	Response	
1	1.00	0.25	.25	FREE-FIELD	ZPA
2	~~2.08~~ 1.48	0.45	.25		2-5 HZ
3	~~1.90~~ 1.68	0.45	.25		5
4	~~1.78~~ 1.66	0.35	.25		5-10
5	~~1.90~~ 1.66	0.35	.25		7
6	~~1.20~~ 1.15	0.35	.25	CS 135	ZPA
7	~~2.50~~ 2.15	0.45	.25		5-10 HZ
8	~~1.40~~ 1.30	0.35	.25	150	ZPA
9	~~3.00~~ 2.50	0.45	.25		5-10
10	~~1.60~~ 1.45	0.35	.25	165	ZPA
11	~~3.30~~ 2.75	0.45	.25		5-10
12	1.00	0.35	.25	RB 91	ZPA
13	~~1.80~~ 1.70	0.45	.25		5-10
14	~~1.80~~ 1.60	0.45	.25		7
15	~~1.80~~ 1.60	0.45	.25		5
16	~~1.10~~ 1.09	0.35	.25	116	ZPA
17	~~2.10~~ 1.80	0.45	.25		7
18	~~1.10~~ 1.07	0.35	.25	135	ZPA
19	~~2.10~~ 1.80	0.45	.25		7
20	~~1.30~~ 1.20	0.35	.25	165	ZPA
21	~~3.00~~ 2.50	0.45	.25		7
22	1.00	0.35	.25	DG 127	ZPA
23	~~1.80~~ 1.70	0.45	.25		5-10
24	~~1.80~~ 1.60	0.45	.25		5
25	1.00	0.35	.25	TB 116	ZPA
26	~~1.90~~ 1.65	0.45	.25		7
27	~~1.30~~ 1.75	0.35	.25	CWPS 114	ZPA
28	~~2.40~~ 2.00	0.45	.25		7
29	~~1.40~~ 1.50	0.35	.25	ECT 153	ZPA
30	~~2.60~~ 2.55	0.45	.25		7
31	~~2.60~~ 2.20	0.45	.25		5
32	1.00	0.00	.25	DUMMY RESPONSE FOR M & S LOCA	

Table 4: LLNL93 (Ref. 2) UHRS Values for Mean 1 x 10^{-4} Annual Exceedance Frequency

freq. F (Hz)	S_V (cm/sec)	S_A (g)	(S_A/PGA)
2.5	17.80	0.285	1.32
5	11.34	0.363	1.68
10	5.50	0.352	1.63
25	2.47	0.396	1.83
PGA	----	0.216	1.00

Table 5: Comparison of LLNL93 (Table 4) Versus 1150 Study (Figure 1) S_A/PGA Ratios

freq. F (Hz)	S_A/PGA 1150 Study (Fig. 1)	S_A/PGA LLNL93 (Table 4)	SF_f	F_f
2.5	2.35	1.32	0.56	0.24
5.0	1.90	1.68	0.88	0.76
7.0	1.90	1.66	0.87	0.73
10.0	1.50	1.63	1.09	1.26
15.0	1.29	1.72	1.33	2.48
25.0	1.07	1.83	1.71	11.9

Table 6 Estimated Response Correction Factors F_f

Case	Struct.	Elev.	f_s (Hz)	f_c (Hz)	F_f
6	CS	135	5	ZPA	0.76
7				5-10	0.76
8		150		ZPA	0.76
9				5-10	0.76
10		165		ZPA	0.76
11				5-10	0.76
12	RB	91	7	ZPA	1.00
13				5-10	0.87
14				7	0.73
15				5	0.76
16		116		ZPA	0.86
17				7	0.73
18		135		ZPA	0.73
19				7	0.73
20		165		ZPA	0.73
21				7	0.73
22	DG	127	20	ZPA	1.00
23				5-10	0.87
24				5	0.76
25	TB	116	10	ZPA	1.00
26				7	0.73
27	CWPS	114	15	ZPA	2.48
28				7	0.73
29	ECT	153	10	ZPA	1.26
30				7	0.96
31				5	0.76

Table 7: Comparison of LLNL93 (Table 4) Versus SSE Design Spectrum (Ref. 4) S_A/PGA Ratios

freq. F (Hz)	S_A/PGA		SF_f
	SSE Design (Ref. 4)	LLNL93 (Table 4)	
2.5	1.83	1.32	0.72
5.0	1.83	1.68	0.92
7.0	1.75	1.66	0.95
10.0	1.67	1.63	0.98
15.0	1.49	1.72	1.15
25.0	1.30	1.83	1.41

Appendix D

Letter Report From R. P. Kennedy (September 1998)

Simplified Approach for
Estimating Seismic Input Levels
Acting on Reactor Internal
Components for Seismic Fragility Analysis

by

Robert P. Kennedy
September 1998

1. Introductory Comments

Reference 1 indicates that a simplified two stick structural model exists for the combined reactor building and internal structure. The internal structure model includes the reactor vessel pedestal, sacrificial shield wall, and reactor pressure vessel. The preferred approach to estimating seismic input levels acting on reactor internal components would be to generate in-structure spectra at various elevations on the reactor pressure vessel using this model subjected to the LLNL93 (Ref. 2) Uniform Hazard Response Spectrum (UHRS) shape for a mean $1x10^{-4}$ annual exceedance frequency. This response spectrum shape (S_A/PGA) is given in Table 1 (taken from Ref. 3) for 5% damping. Either direct generation of in-structure spectra for this input spectrum, or time-history generation could be used so long as the time-history produces a 5% damped response spectrum which closely approximates the (S_A/PGA) ratios listed in Table 1.

However, it is my understanding that time and budget constraints may not allow this preferred approach to be used. Therefore, the remainder of this report defines a simple approximate approach for estimating seismic input levels acting on reactor internal components. I believe that this simple approach will enable the seismic input to reactor internal components to be estimated with the same degree of accuracy as that obtained for all other components whose seismic fragilities have been estimated in Ref. 1 and modified in Ref. 3 to be consistent with the UHRS of Ref. 2.

2. Basic Approach for Estimating Seismic Fragilities

By Ref. 1, the median fragility A_{50} defined in terms of peak ground acceleration (PGA) is given by:

$$A_{50} = \frac{M_F}{M_R} \tag{1}$$

RPK **Structural Mechanics Consulting**
18971 Villa Terrace, Yorba Linda, CA 92886
714 777-2163 • 714 777-8299

where M_F is the median component fragility defined in terms of input at its support, and M_R is a response multiplication factor which is a function of the component natural frequency and support location. Then:

$$\beta_R = \left[\beta_{FR}^2 + \beta_{RR}^2\right]^{1/2}$$
$$\beta_U = \left[\beta_{FU}^2 + \beta_{RU}^2\right]^{1/2} \quad (2)$$

where β_R and β_U are the overall randomness, and uncertainty variabilities, respectively; β_{FR} and β_{FU} are the corresponding fragility randomness and uncertainty variabilities; and β_{RR} and β_{RU} are the corresponding response randomness and uncertainty variabilities.

The remainder of this report concerns itself with estimating the median response multiplication factor M_R and variabilities β_{RR} and β_{RU} for reactor internal components.

3. Estimates of Median Response Factor M_R for Reactor Internals

Figure 1 (reproduction of Figure 4.10c from Ref. 1) presents 5% damped in-structure spectra at various elevations on the reactor building internal structure model subjected to a 0.24g PGA input. Median spectral accelerations S_A are tabulated in Table 2 (reproduction of page B-5 of Ref. 1) for various elevations on the reactor building internal structure and component natural frequencies for this 0.24g PGA

From Table 2, an original median response factor M_{RO} can be obtained for various elevations and component frequencies from:

$$M_{RO} = \frac{S_A}{0.24g} \quad (3)$$

However, this original response factor M_{RO} is based upon an input ground motion response spectrum shape which is not consistent with the Ref. 2 UHRS shape recommended for use in Ref. 3. To correct for this difference in input ground motion response spectra shapes, Ref. 3 recommends that a revised response factor M_{RR} can be approximately estimated based on the original response factor M_{RO} using:

$$M_{RR} \approx 1 + (M_{RO} - 1)F_f \quad (4)$$

where F_f is a frequency dependent correction factor given by:

$$F_f = \frac{AFN_f - 1}{AFO_f - 1} \tag{5}$$

where:

AFN_f = LLNL93(Table 1) $(S_A/PGA)_f$
AFO_f = 1150 Study $(S_A/PGA)_f$

These F_f factors from Eqn. (5) are given in Table 3 (taken from Ref. 3) as a function of frequency f. The use of F_f values substantially different from unity is suspect and must be done with caution. For any case, judgement must be exercised in selecting the natural frequency at which F_f is to be obtained.

For cases where the component frequency f_c is greater than or approximately equal to the structure frequency f_s, the factor F_f should be estimated at the structure frequency f_s for components located above the approximate C.G. height within the structure. For components located on the base of the structure, the factor F_f should be estimated at the component frequency f_c. Interpolation between these two F_f values needs to be used for components located between the base and CG height in the structure. For the reactor building internal structure f_s is approximately 7 Hz and I expect the C.G. height to be about Elev. 146 or lower.

For cases where $f_c \leq (f_s/2)$, the factor F_f should be based on the component frequency f_c. For cases where $(f_s/2) < f_c < f_s$, interpolation between F_f based on f_s and F_f based on f_c is required.

Table 4 presents the original response factors M_{RO} at various elevations and component frequencies obtained from Table 2 and Eqn. (3). Also presented are my estimates of the appropriate correction factor F_f following the above described guidance, and the resulting revised response factor M_{RR} obtained from Eqn. (4).

For each reactor internal component, I recommend that the median spectral acceleration capacity M_F be estimated and that the median PGA fragility A_{50} be determined from Eqn. (1) using the appropriate M_{RR} response factor from Table 4.

Since the lower head of the reactor vessel is at Elev. 148'-3" and the top of the active fuel is at Elev. 178'-3", I would expect that the Elev. 156' and Elev. 169' values from Table 4 would generally be most applicable for reactor internals.

4. Estimate of Response Variabilities β_{RR} and β_{RU}

Within the reactor building, Ref. 1 estimates that the following response variabilities are appropriate:

	f_c	
	7 Hz	ZPA
β_{RR}	0.45	0.35
β_{RU}	0.25	0.25

In general, I consider the Ref. 1 β_{RR} values to be high. However, because of the crude frequency categories used in Ref. 1 to define M_{RO}, and because of the need to modify these median response factors to M_{RR} because of the different input ground motion, I recommend continuing to use the Ref. 1 values for β_{RR}.

In general, I also consider the Ref. 1 β_{RU} values to be slightly high. However, because of the need to convert M_{RO} to M_{RR}, I would recommend their retention. In addition Ref. 1 is unclear as to whether the Table 2 spectral accelerations S_A are for locations on the reactor vessel or whether they are for locations on the concrete internal structure. I suspect that the latter is true. Therefore, some additional β_{RU} should be included to account for the uncertainty of using the Table 4 response factors M_{RR} for reactor internals mounted to the reactor vessel.

In summary, I recommend using the following response variabilities for reactor internals:

f_c (Hz)	β_{RR}	β_{RU}
2-5	0.40	0.30
5-10	0.45	0.30
7	0.45	0.30
10	0.40	0.30
ZPA	0.35	0.30

References

1. [Plant-Specific Reference]

2. Sobel, P., *Revised Livermore Seismic Hazard Estimates for 69 Nuclear Power Plant Sites East of the Rocky Mountains,* NUREG-1488, US NRC, Oct. 1993

3. Kennedy, R.P., *Suggested Upgrading of NUREG-1150 Seismic Risk Assessment of For Use in Intergranular Stress Corrosion Cracking Risk Assessment.* August 1998

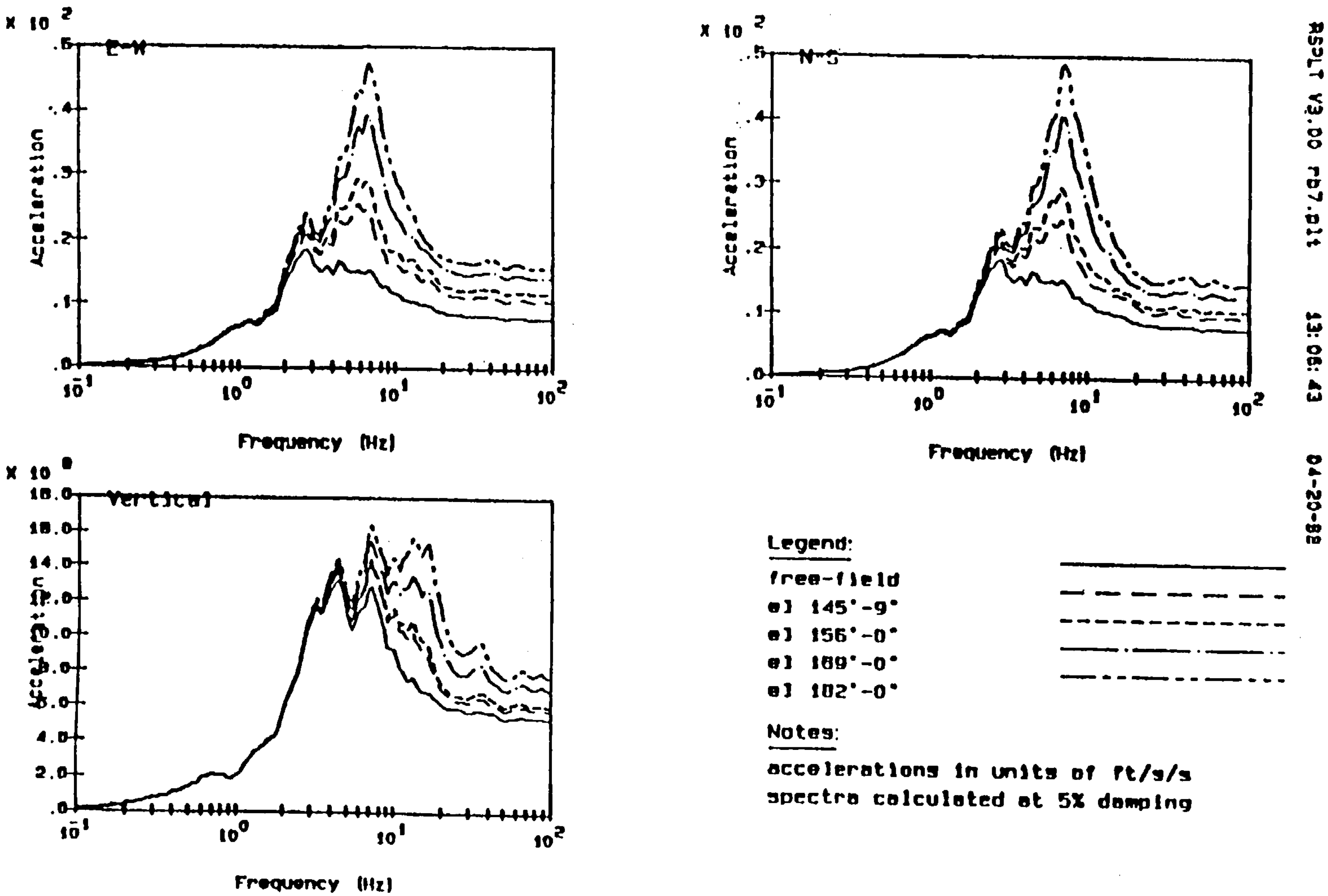


Figure 1 (Copy of Fig. 4.10c from Ref. 1)

Figure 4.10c. Containment Bldg Instructure Responses for Acceleration Range 2

Table 1: LLNL93 (Ref. 2) UHRS Values for Mean 1 x 10^{-4} Annual Exceedance Frequency

freq. F (Hz)	S_V (cm/sec)	S_A (g)	(S_A/PGA)
2.5	17.80	0.285	1.32
5	11.34	0.363	1.68
10	5.50	0.352	1.63
25	2.47	0.396	1.83
PGA	----	0.216	1.00

Table 2: (Copy of Page B-5 from Ref. 1)

MEDIAN RESPONSE
REACTOR/CONTAINMENT BUILDING
ACCELERATION RANGE 2 (g)

REACTOR/CONTAINMENT BLDG

el.	dir.	2-5 (Hz)	5-10 (Hz)	7 (Hz)	10 (Hz)	zpa
91'-0"	x	.50	.43	.44	.36	.25
91'-0"	y	.50	.43	.44	.36	.25
91'-0"	z	.33	.34	.35	.28	.17
135'-0"	x	.54	.49	.51	.39	.27
135'-0"	y	.53	.48	.50	.38	.25
135'-0"	z	.33	.36	.37	.31	.18
165'-0"	x	.62	.67	.70	.51	.33
165'-0"	y	.60	.65	.69	.47	.30
165'-0"	z	.34	.39	.40	.35	.19
195'-0"	x	.69	.91	.97	.67	.41
195'-0"	y	.65	.87	.92	.64	.36
195'-0"	z	.34	.41	.42	.39	.21
234'-0"	x	.77	1.24	1.32	.95	.52
234'-0"	y	.70	1.12	1.18	.87	.44
234'-0"	z	.34	.42	.43	.41	.22
252'-0"	x	.85	1.62	1.72	1.29	.67
252'-0"	y	.75	1.43	1.49	1.22	.55
252'-0"	z	.35	.46	.46	.46	.25
286'-0"	x	.99	2.51	2.62	2.31	.99
286'-0"	y	.82	1.86	1.92	1.75	.74
286'-0"	z	.36	.50	.50	.53	.28

REACTOR

el.	dir.	2-5 (Hz)	5-10 (Hz)	7 (Hz)	10 (Hz)	zpa
119'-11"	x	.52	.46	.47	.38	.25
119'-11"	y	.52	.45	.47	.37	.25
119'-11"	z	.33	.35	.37	.30	.17
135'-0"	x	.57	.54	.56	.44	.29
135'-0"	y	.56	.53	.55	.42	.27
135'-0"	z	.33	.37	.38	.32	.18
145'-9"	x	.60	.64	.67	.51	.33
145'-9"	y	.59	.64	.67	.49	.30
145'-9"	z	.33	.38	.39	.34	.18
156'-0"	x	.64	.74	.78	.58	.37
156'-0"	y	.62	.75	.79	.57	.34
156'-0"	z	.34	.38	.39	.35	.19
169'-0"	x	.71	.99	1.05	.75	.45
169'-0"	y	.68	1.03	1.09	.79	.41
169'-0"	z	.34	.42	.42	.41	.22
182'-0"	x	.75	1.20	1.27	.92	.50
182'-0"	y	.72	1.24	1.31	.98	.47
182'-0"	z	.35	.44	.45	.45	.24
195'-0"	x	.78	1.32	1.39	1.05	.55
195'-0"	y	.74	1.35	1.41	1.10	.52
195'-0"	z	.35	.46	.47	.48	.25

Table 3: Comparison of LLNL93 (Table 1) Versus 1150 Study S_A/PGA Ratios

freq. F (Hz)	S_A/PGA		F_f
	1150 Study	LLNL93 (Table 1)	
2.5	2.35	1.32	0.24
5.0	1.90	1.68	0.76
7.0	1.90	1.66	0.73
10.0	1.50	1.63	1.26
15.0	1.29	1.72	2.48
25.0	1.07	1.83	11.9

Table 4: Recommended Revised Response Factors M_{RR} At Various Elevations on Reactor Internal Structure

Elev.	Component Frequency f_c (Hz)	Original Response Factor M_{RO}	Correction Factor F_F	Revised Response Factor M_R
145'-9"	2-5	2.5	0.43	1.6
	5-10	2.7	0.73	2.2
	7	2.8	0.73	2.3
	10	2.1	0.73	1.8
	ZPA	1.3	0.73	1.2
156'-0"	2-5	2.6	0.43	1.7
	5-10	3.1	0.73	2.5
	7	3.3	0.73	2.7
	10	2.4	0.73	2.0
	ZPA	1.5	0.73	1.3
169'-0"	2-5	2.9	0.43	1.8
	5-10	4.2	0.73	3.3
	7	4.5	0.73	3.5
	10	3.2	0.73	2.6
	ZPA	1.8	0.73	1.6
182'-0"	2-5	3.1	0.43	1.9
	5-10	5.1	0.73	4.0
	7	5.4	0.73	4.2
	10	4.0	0.73	3.2
	ZPA	2.0	0.73	1.7
195'-0"	2-5	3.2	0.43	1.9
	5-10	5.6	0.73	4.3
	7	5.8	0.73	4.5
	10	4.5	0.73	3.5
	ZPA	2.2	0.73	1.9

Appendix E

Scientech Trac-B Report

In-Vessel Recirculation Line Break Transient Calculation for

DRAFT

Christer Dahlgren

August 1998

SCIENTECH, Inc.
11140 Rockville Pike, Suite 500
Rockville, MD 20852

INTRODUCTION

This calculation was performed as part of the support of the BWR component failure program. The purpose of this calculation is to provide thermal and hydraulic information to support the assessment of failure of the jet pumps. The assessment of BWR component failure is to be conducted by the INEEL.

The break was postulated to occur in the part of the recirculation line that is located inside the vessel component. This part is called the jet pump riser. The break is assumed to occur during normal operation. No inventory will be lost during this break. Instead, the affected jet pump pair will be disabled due to the break, and the liquid will be re-directed from the recirculation line into the downcomer of the vessel component. The liquid which exits the break into the downcomer will create a liquid jet which will impinge on the jet pump riser. The purpose of this calculation is to provide the boundary conditions for failure calculations on the affected jet pump riser. The results of the analysis are presented below in the discussion section. A summary of the results and concluding remarks are presented in the conclusion section.

In the calculation, the break is assumed to occur at the inlet of the recirculation line to the vessel component. The elevation of the inlet is 4.74 m, which is 0.62 m higher than the center elevation of cell 13, level 3, shown in Figure 1. In the steady state model, the recirculation line piping outside and inside the vessel is modeled with component 34. Figure 2 shows the azimuthal section containing the riser and jet pump pair that are affected by the break. For the purpose of calculating the break flow, the recirculation line component had to be split up into a tee component (component number 34) and a pipe component (number 36), as shown in Figure 3. Figure 4 presents the connections of component 34 and 36 to the vessel level 3 cell 13.

The following parameters are presented in Figure 5 to 36:

Break Parameters:
Mass Flow Rate in the broken side of the recirculation line (Figure 5 and 6)
Liquid Velocity in the broken side of the recirculation line (Figure 7 and 8)
Upstream Break Pressure (Figure 9 and 10)
Upstream Break Temperature (Figure 11 and 12)
Mass Flow Rate in the intact side of the recirculation line (Figure 13 and 14)

Jet Pump Parameters:
Mass Flow Rate in jet pump components 5 and 55 (Figure 15 and 16)
Mass Flow Rate in jet pump component 30 and 80 (Figure 17 and 18)

Vessel Parameters:

Pressure in Vessel Level 3, Cell 13 (downstream of break), and Level 4 and Cell 13 (Figure 19 and 20)
Differential Pressure between level 4 and 3 in Cell 13 (Figure 21 and 22)
Differential Pressure between cell 13, 14 and 16 in level 3 (Figure 23 and 24)
Azimuthal Liquid velocities in and out of cell 13, level 3 (Figure 25 and 26)

System Parameters:
Total Reactor Power (Figure 27 and 28)
Steam Dome Pressure (Figure 29 and 30)
Steam Line and Feedwater Mass Flow Rates (Figure 31 and 32)
Recirculation Pump 1 and 2 Mass Flow Rates (Figure 33 and 34)
Peak Cladding Temperature for Hot Channel Component 4 (Figure 35 and 36)

All parameters have been plotted with two different time scales, 0-100 sec, and 0-0.2 sec. The shorter time scale was included to show the initial transient behavior of the break parameters. The larger time scale shows the system properties reaching a quasi-steady operational state after the break opened which differed from the initial steady state. The first 0.20 sec of the transient was calculated using a time step of 0.001 sec. This time step was based on the sonic courant limit for the cell upstream of the break location. The courant limit for this cell is:

$$\Delta x/u_{sonic} = 3.82/1100 \text{ sec} = 0.0031 \text{ sec}$$

This time step was necessary to capture the decrease in pressure in the recirculation line. Every calculated time step is plotted, but for reasons of clarity, a symbol is only attached to every fifth data point.

The remainder of the transient was calculated using a time step of 0.01 sec, which was lower than the courant limit of the system (0.013 sec). The courant limit for this part of the transient was limited by valve component 59, which represents the pressure control valve in the steam line.

DISCUSSION

This section will discuss results of the calculation and the changes in the key parameters during this transient.

Figures 1 to 4 (attached) show a simplified diagram of the break location from the side and from above, the connection of the broken pipe to the vessel cell, and the nodalization diagram of the renodalization of tee component 34.

Changes in Break Parameters:
In the first 0.1 sec, the break mass flow rate increased from 435 kg/s to 621 kg/s (Figure 5). This represents an increase of 42.8%. The mass flow rate stayed approximately

~1025 PSI constant from then on (Figure 6). The corresponding liquid velocity changed from 8.1 m/s to 11.6 m/s (Figure 7 and 8). The pressure upstream of the break changed from 8.32 MPa to 7.07 MPa in 0.025 sec (Figure 9). ~1207 PSI This represents a decrease of 15%. The pressure at the end of the transient (100 sec) was 6.92 MPa (Figure 10). The temperature upstream of the break changed only slightly; from 548.3 K to 547.9 K (Figure 11 and 12). The mass flow rate of the unbroken side in the broken recirculation line changed from 1755 kg/s to 1665 kg/s in the first 0.07 sec after the break (Figure 13), but later returned to a value closer to the initial steady state value (Figure 14). The mass flow rate in the unbroken side was 1732 kg/s at the end of the transient. The state of the break flow was single phase liquid throughout the transient.

Changes in Jet Pump Parameters:
Jet pump component 5 represents the jet pump pair which is connected to the broken riser. The flow in this component was reversed. The flow changed from 1255 kg/s to -450 kg/s in 2 sec (Figure 16). The mass flow rates of the rest of the jet pump component increased. The mass flow rate in jet pump components 30 (which represent 4 jet pump pairs connected to the broken recirculation line) increased from 5040 kg/s to approximately 5175 kg/s. The mass flow rate in jet pump component 80 (which represent 4 jet pump pairs connected to the intact recirculation line) increased from 5040 to 5300 kg/s (Figure 18). The mass flow rate in jet pump component 55 (which represents one jet pump pair located 180 degrees from jet pump component 5) changed from 1255 to 1305 kg/s (Figure 16).

Changes in Vessel Parameters:
Figure 21 presents the difference in pressure between the vessel cell downstream of the break (Level 3, Cell 13) and in the cell above (Level 4, Cell 13). The pressure difference reached a maximum of 81000 Pa after 0.003 sec. The pressure difference in the azimuthal direction reached a maximum of 75000 Pa after 0.002 sec, and a minimum of -26000 Pa after 0.007 sec (Figure 23).

Changes in System Parameters:
The total core power decreased from the initial value of 3290 MW to 2550 MW in approximately 1.5 sec after the break (Figure 28). At the end of the transient, the core power was 3020 MW and steady. This represents an 8.2% decrease with respect to the initial conditions. The steam dome pressure is initially 7.063 MPa (Figure 29). At the end of the transient it is 6.85 MPa, and steady (Figure 30), which is about 3.0% lower than the initial conditions. The steam and feedwater line mass flow rates were initially 1710 kg/s (Figure 31). At the end of the transient, both mass flow rates had decreased by 8.5% to approximately 1565 kg/s (Figure 32). The recirculation pumps mass flow rates was initially 2180 kg/s (Figure 33). At the end of the transient, the mass flow rate for the recirculation line pump feeding the break increased by 7.5% to 2345 kg/s. The mass flow rate of the other recirculation line increased slightly from 2180 kg/s to 2200 kg/s (Figure 34). The peak cladding temperature (PCT) remained at the initial value of 579.6 K throughout the transient (Figure 35 and 36).

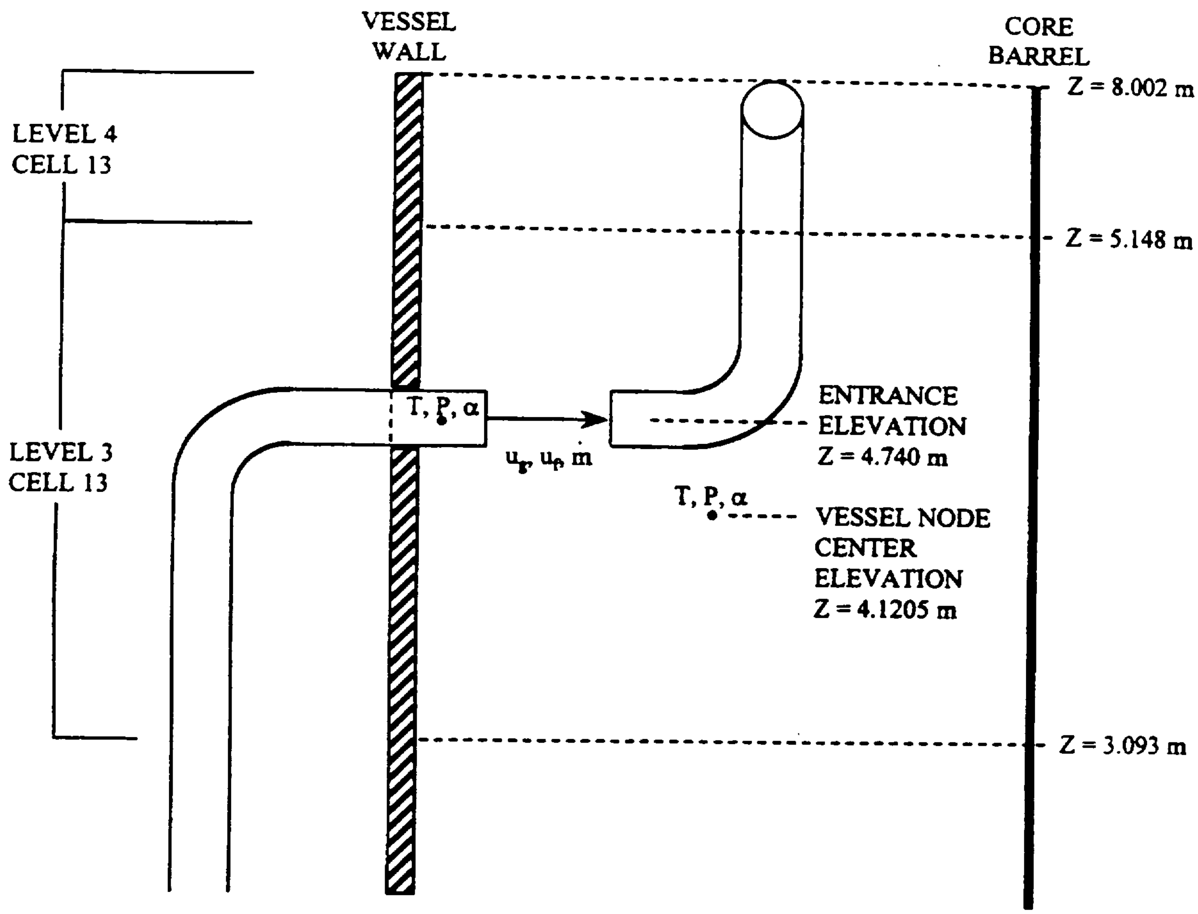
CONCLUSIONS

This calculation was performed in the support of the BWR component failure program. The calculations that were performed consisted of an in-vessel recirculation line break. The transient calculation showed the following changes in the key parameters:

Break mass flow rate: An instantaneous increase of 42.8% from the initial value of 435 kg/s to 621 kg/s is observed (see Figure 5).
Break Pressure: The pressure upstream of the break location is shown to decrease from 8.32 MPa to 7.07 MPa shortly after the break (see Figure 9).
Vessel Pressure: The pressure in the vessel cell in which the break is located increases from 7.14 MPa to 7.22 MPa shortly after the break (see Figure 19).
Break velocity: Since the density is not changing much, the velocity of the break flow increases with 42.8% from the initial value of 8.1 m/s (see Figure 7).
Break Temperature: Does not change significantly from the initial value of 548.3 K at the beginning of the transient (see Figure 11). At the end of the transient the temperature of the break flow is 545.6 K.

It was also shown that the system parameters re-established a quasi-steady condition after the break opened. The new state condition total core power was calculated to be 8.2% lower than the initial level of 3290 MW. The steam and feedwater mass flow rate was 8.5% lower than the initial value of 1710 kg/s. Due to the break in one of the recirculation lines, the mass flow rate through both pumps driving the recirculation line flow became asymmetrical. The flow in recirculation pump 1 (which is connected to the broken recirculation line) increased by 7.5% from the initial value of 2180 kg/s. The mass flow rate in the intact recirculation line pump changed slightly from the initial steady state value to 2200 kg/s.

The break parameter data will be supplied to the INEEL.



T_{pipe}, $T_{vessel\ node}$	=	TEMPERATURES [K]
u_f, u_g	=	VELOCITIES [m/s]
$\dot{m}$	=	MASS FLOW RATE [kg/s]
P_{pipe}, $P_{vessel\ node}$	=	PRESSURES [Pa]
α_{pipe}, $\alpha_{vessel\ node}$	=	VOID FRACTIONS [-]

Figure 1: Simplified Break Nodalization, Side View

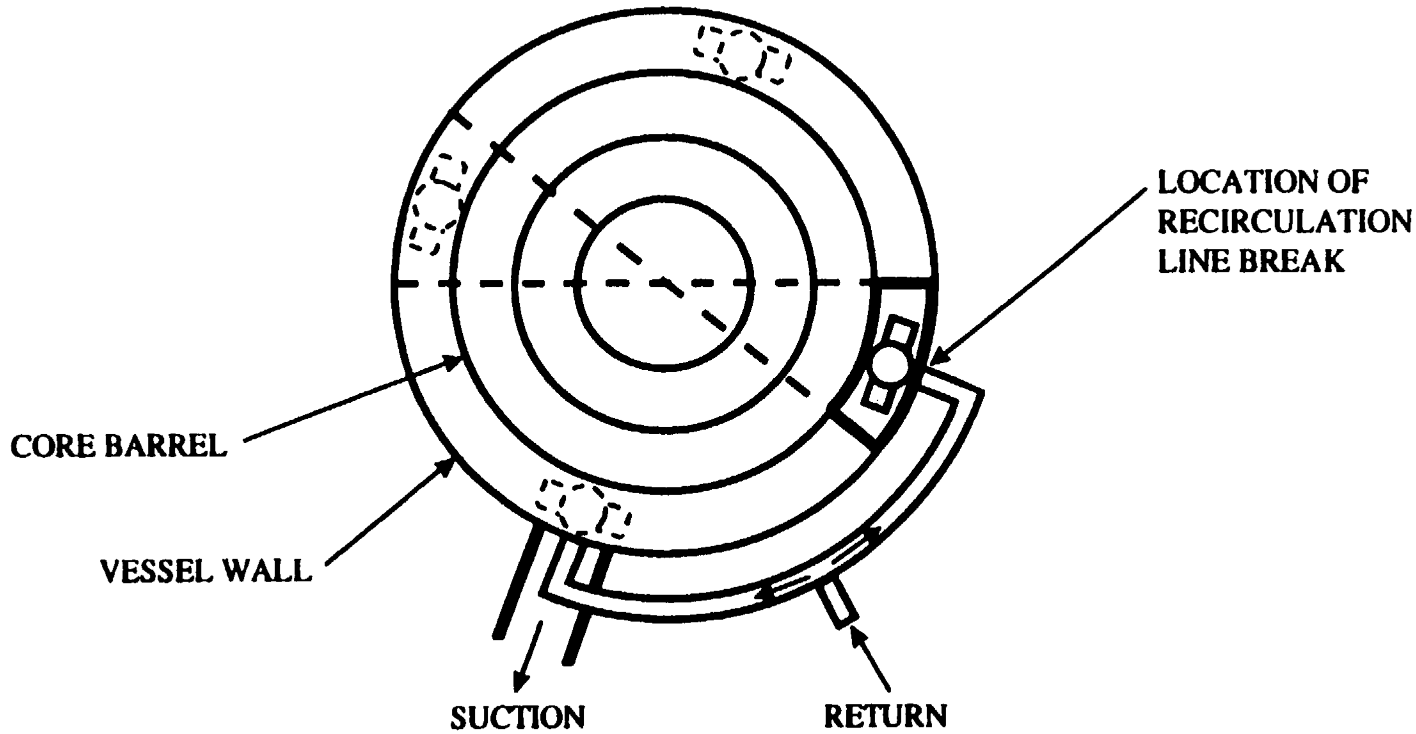


Figure 2: Break Location, View from Above

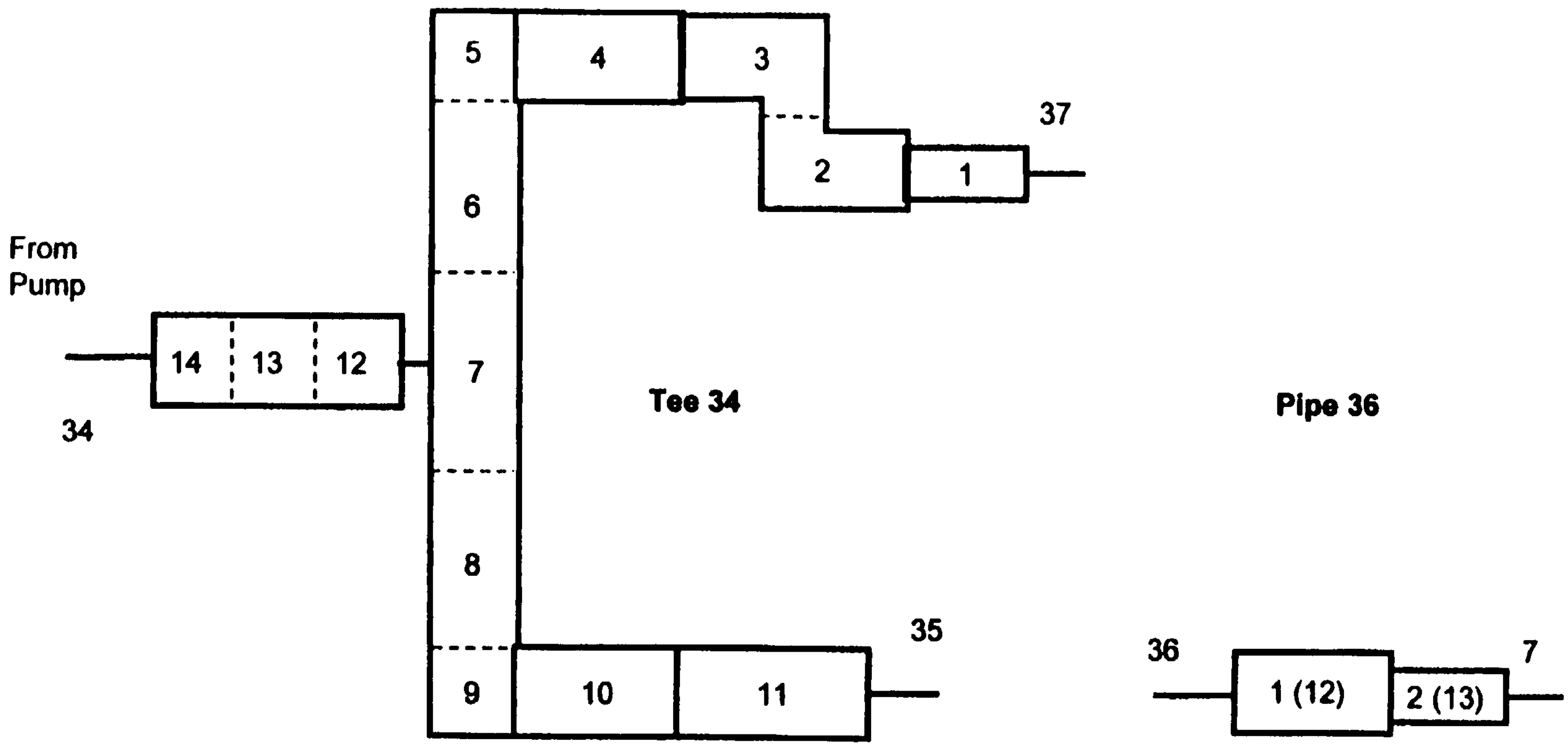


Figure 3: Renodalization of Tee Component 34

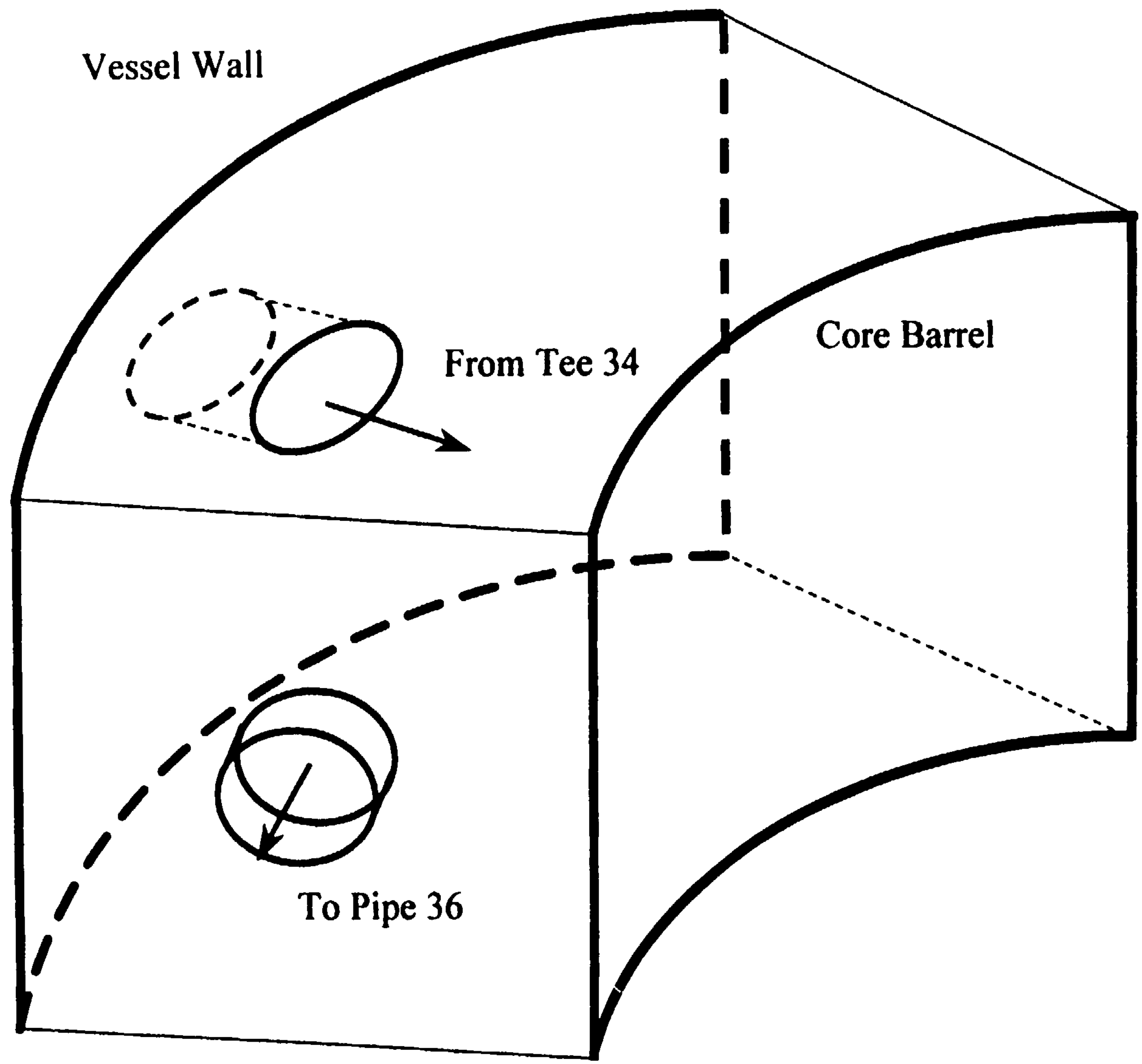


Figure 4: Connection of Components 34 and 36 to the Vessel Cell

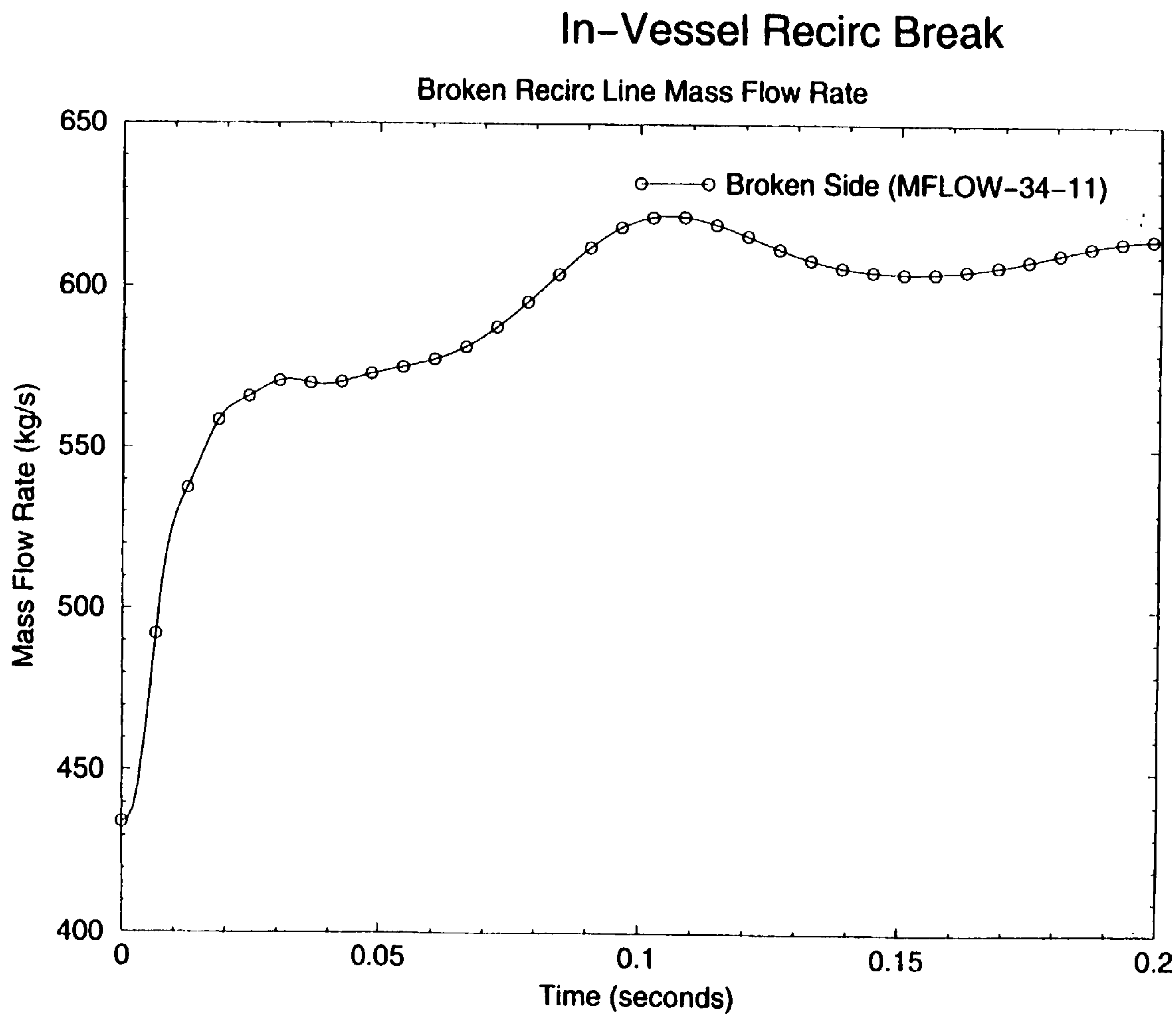


Figure 5: Mass Flow Rate in the Broken Side of the Recirculation Line (0-0.2 sec)

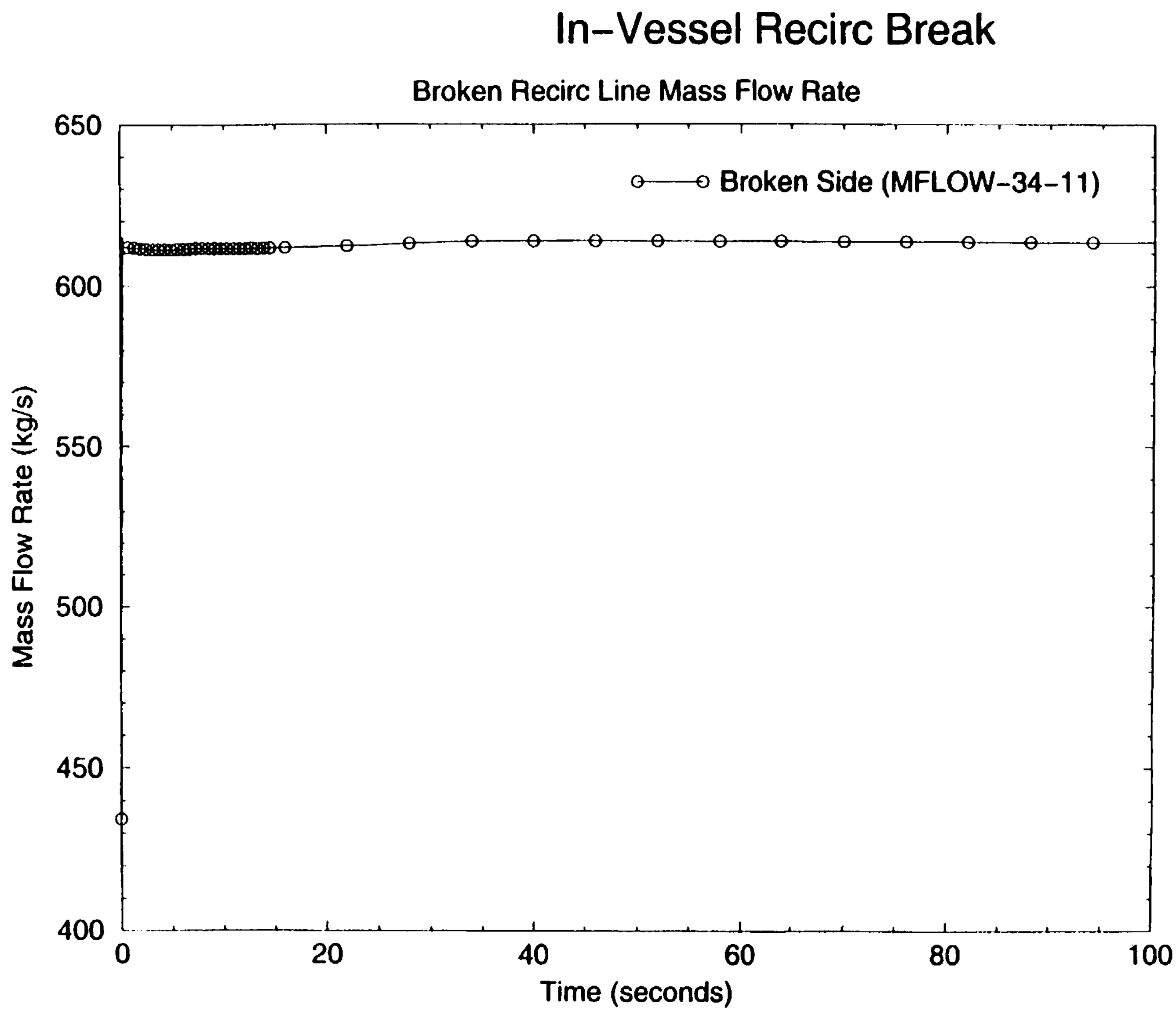


Figure 6: Mass Flow Rate in the Broken Side of the Recirculation Line (0-100 sec)

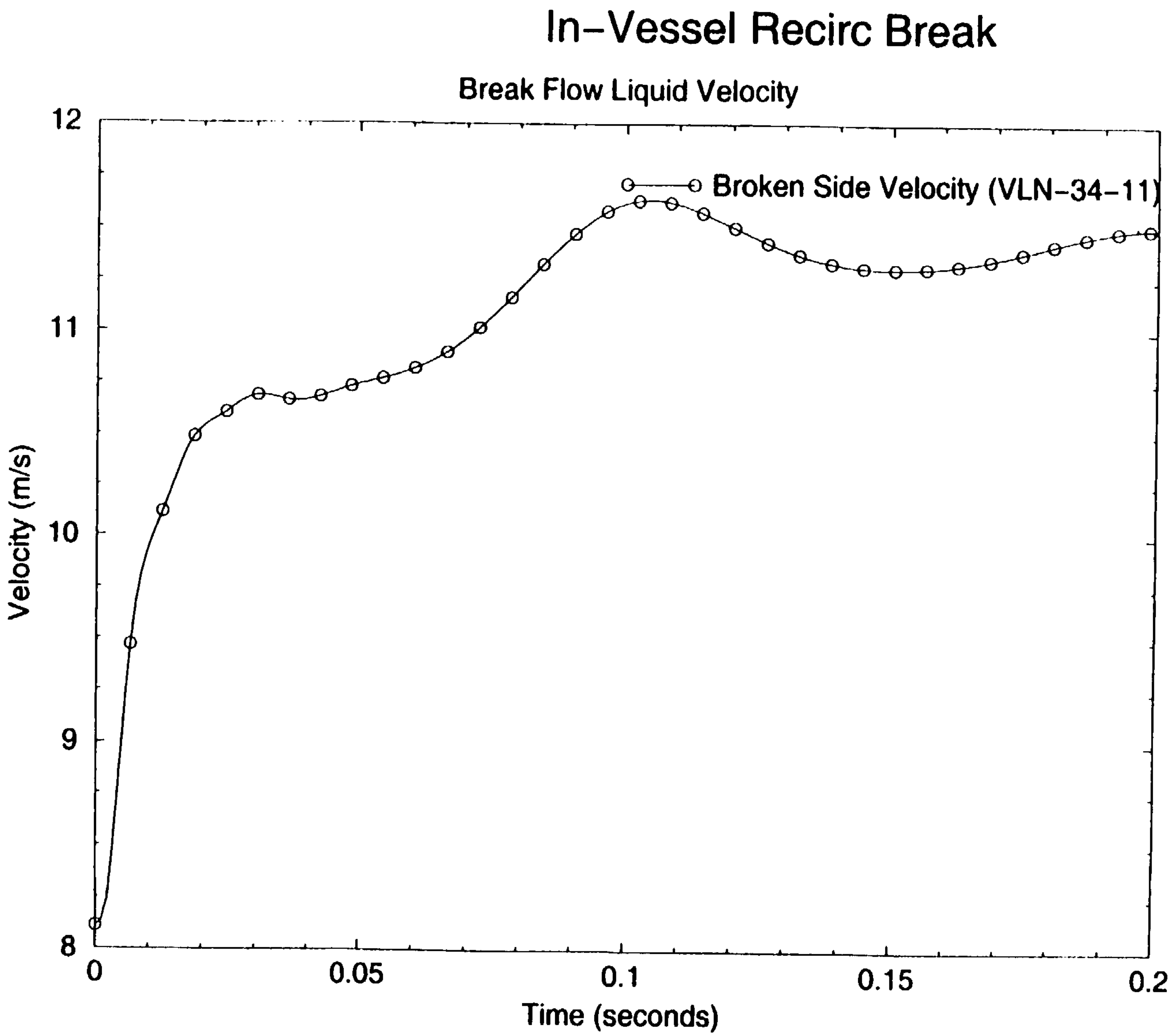


Figure 7: Liquid Velocity in the Broken Side of the Recirculation line (0-0.2 sec)

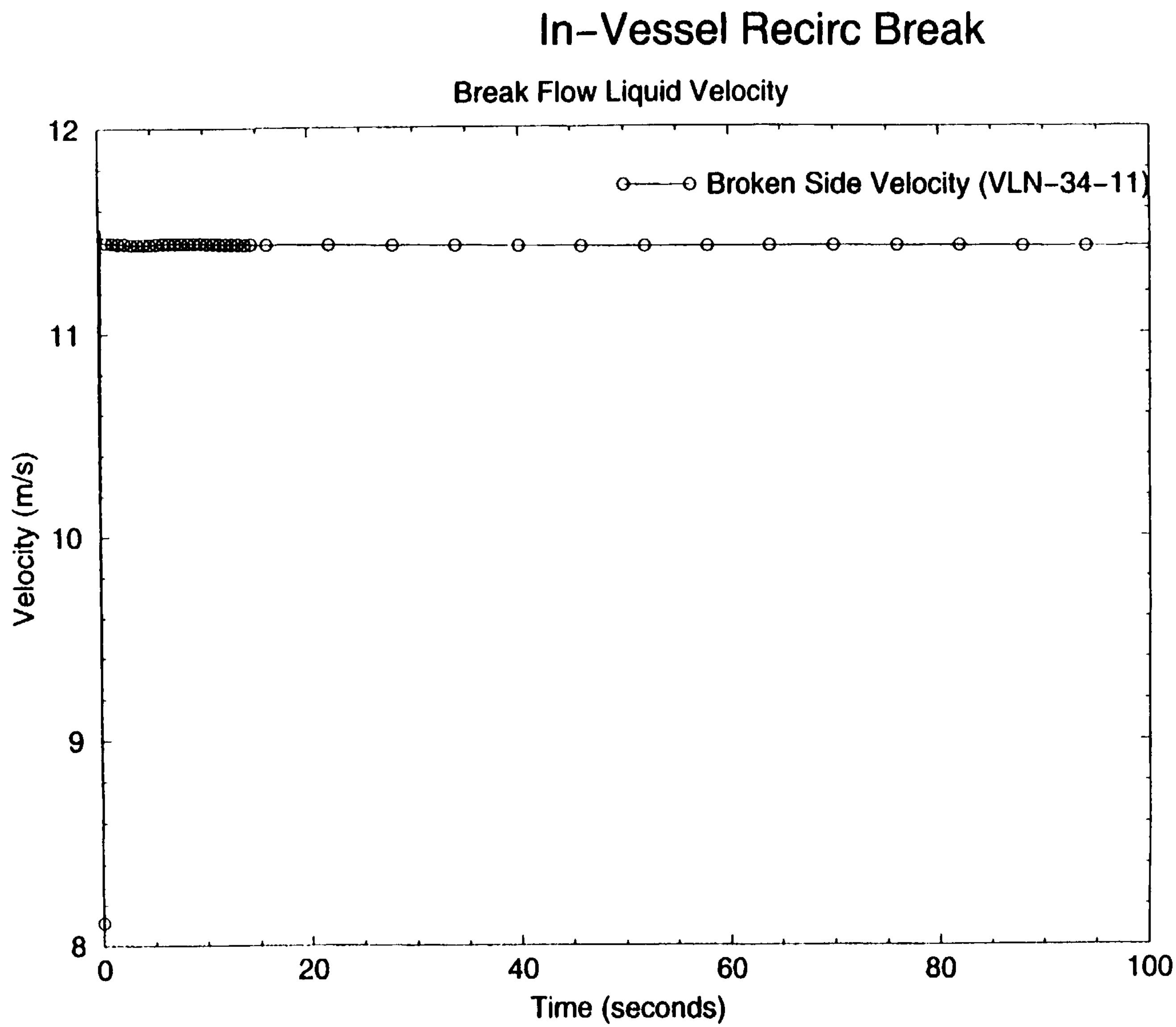


Figure 8: Liquid Velocity in the Broken Side of the Recirculation line (0-100 sec)

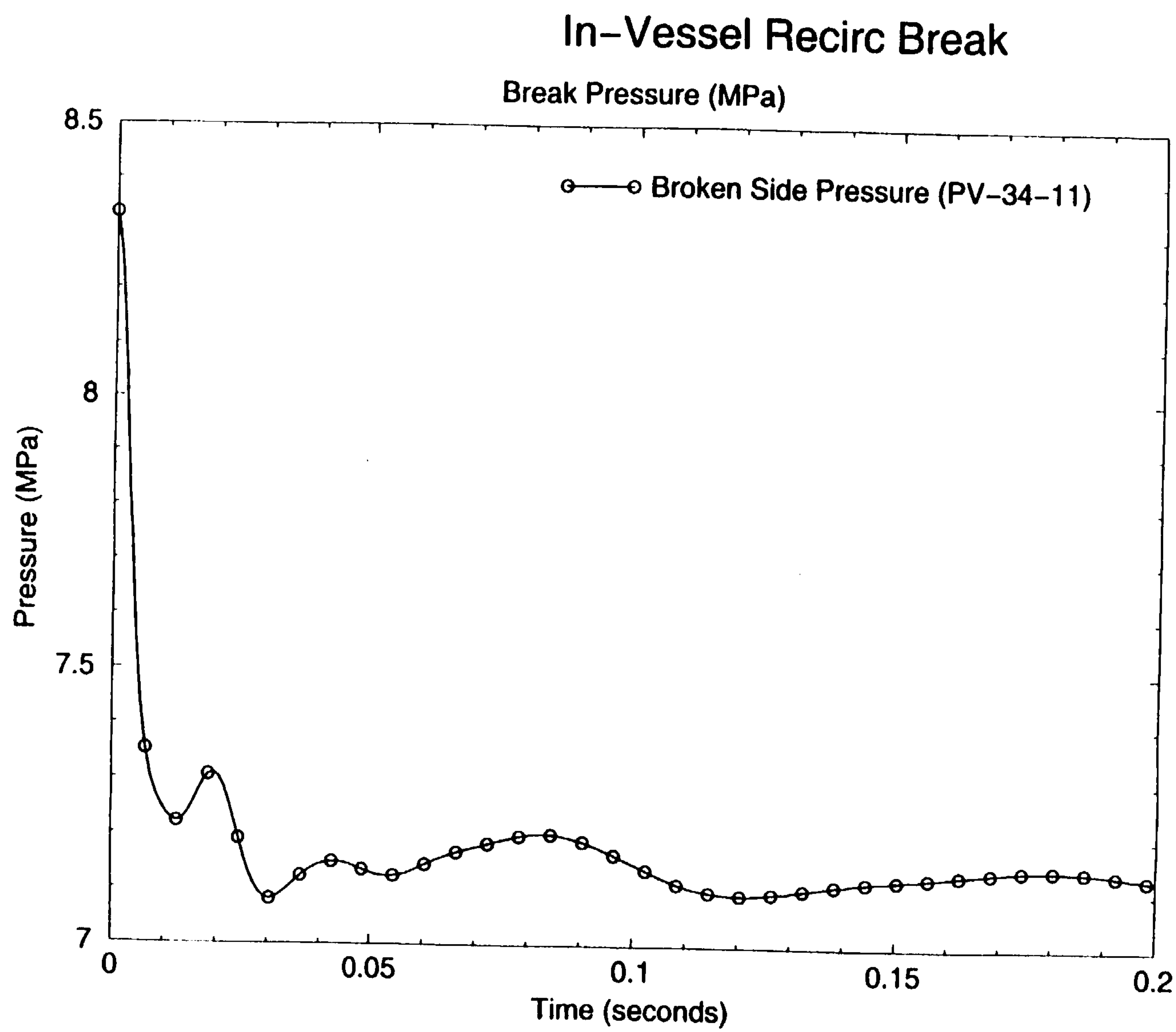


Figure 9: Upstream Break Pressure (0-0.2 sec)

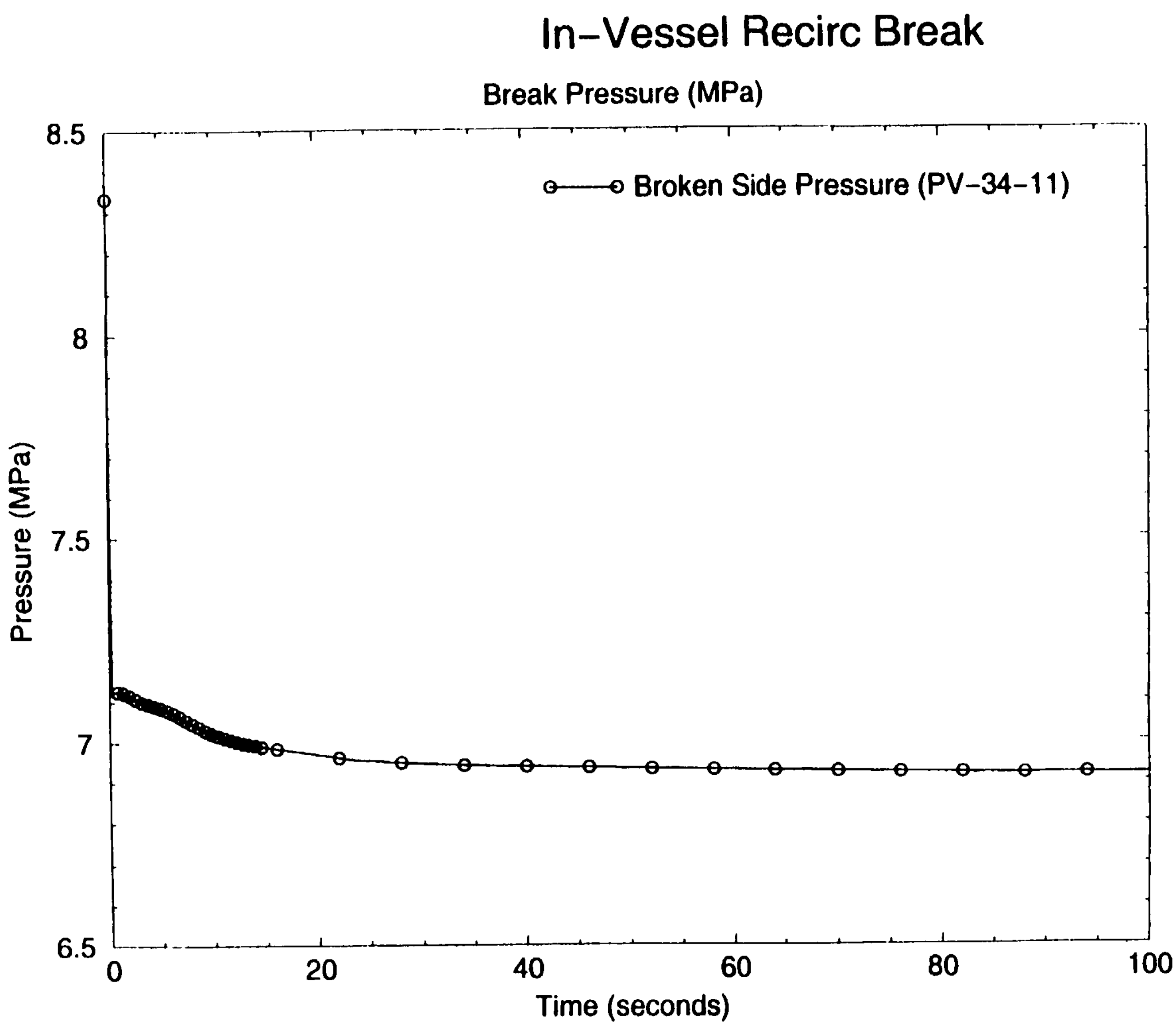


Figure 10: Upstream Break Pressure (0-100 sec)

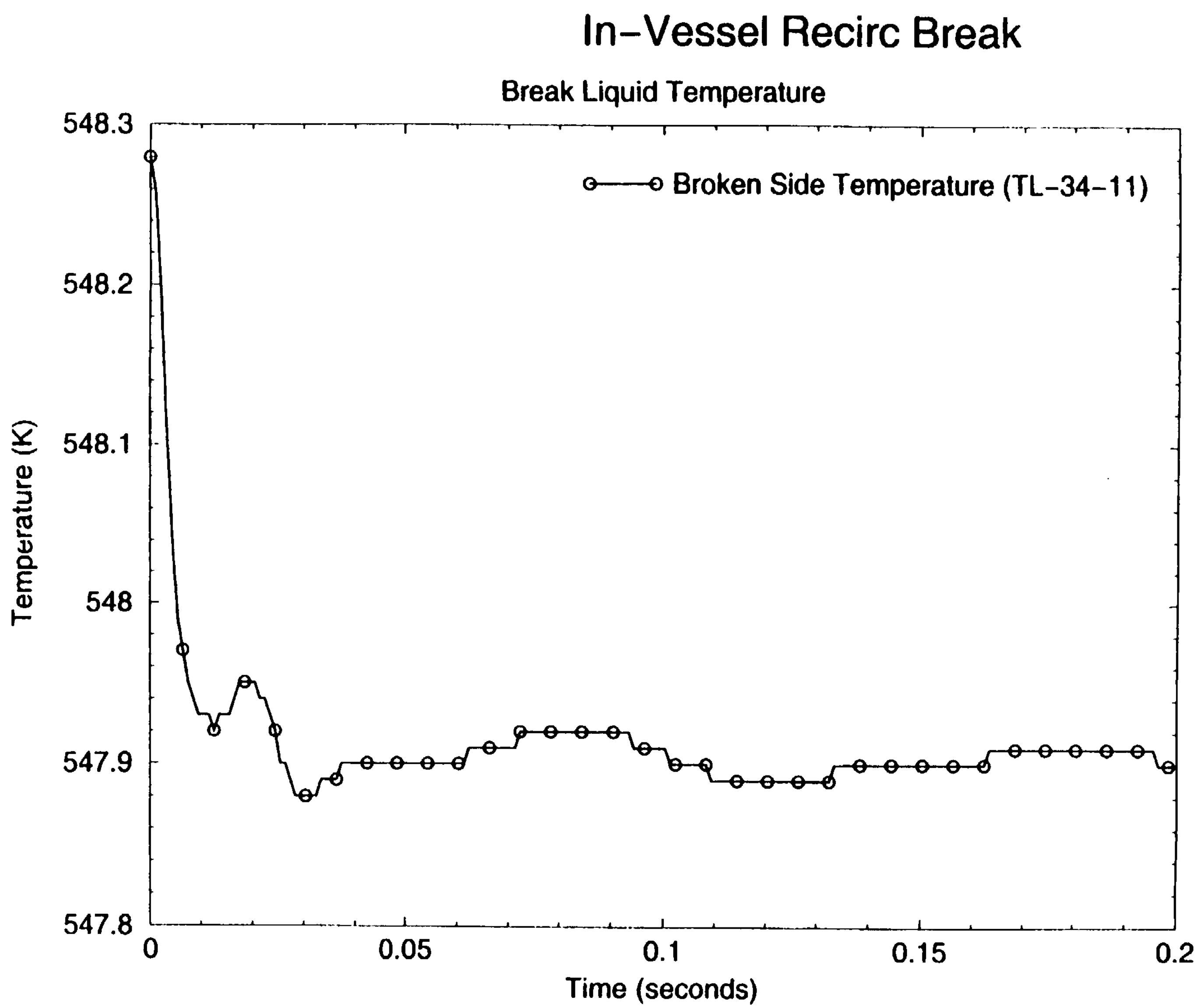


Figure 11: Upstream Break Temperature (0-0.2 sec)

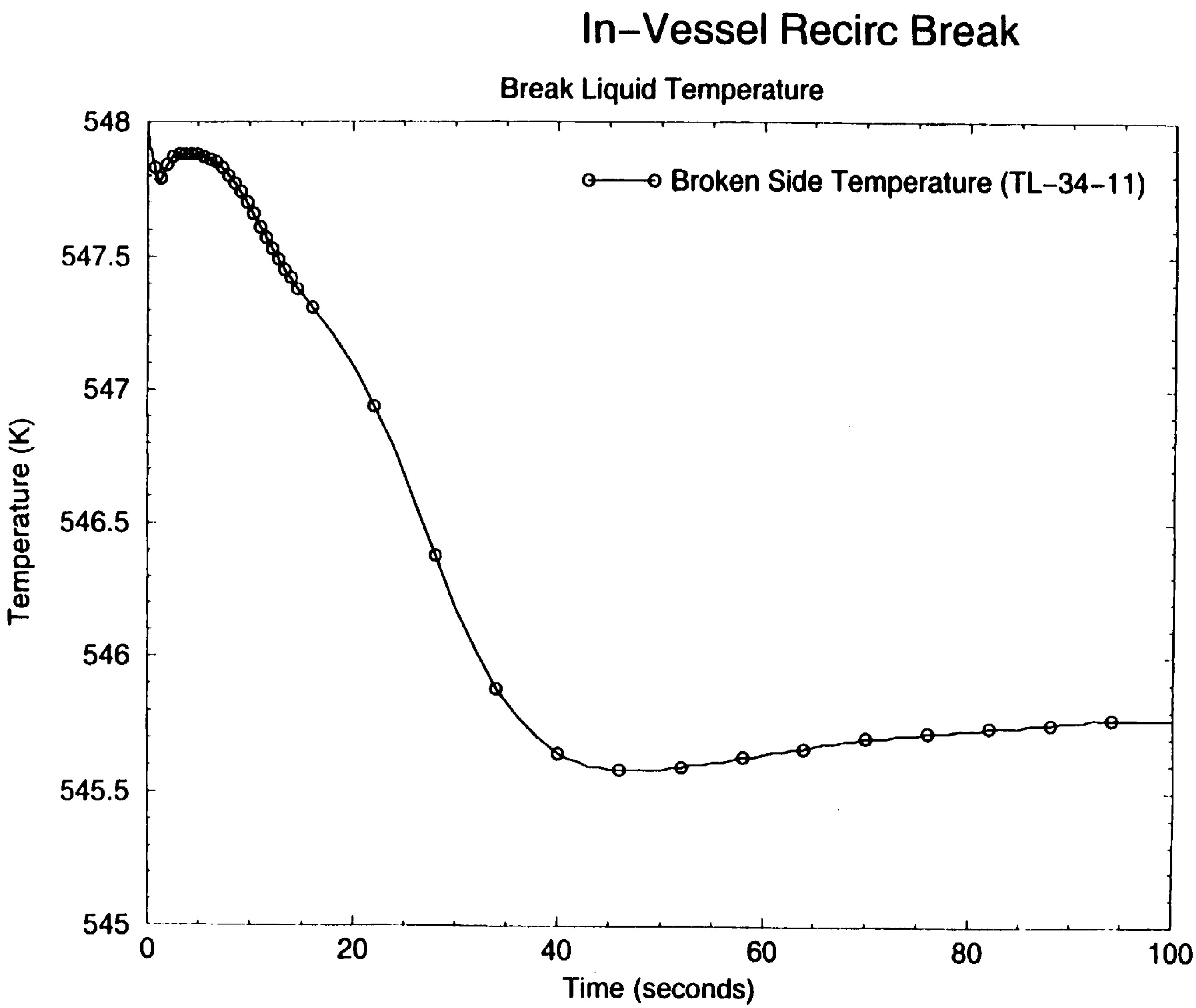


Figure 12: Upstream Break Temperature (0-100 sec)

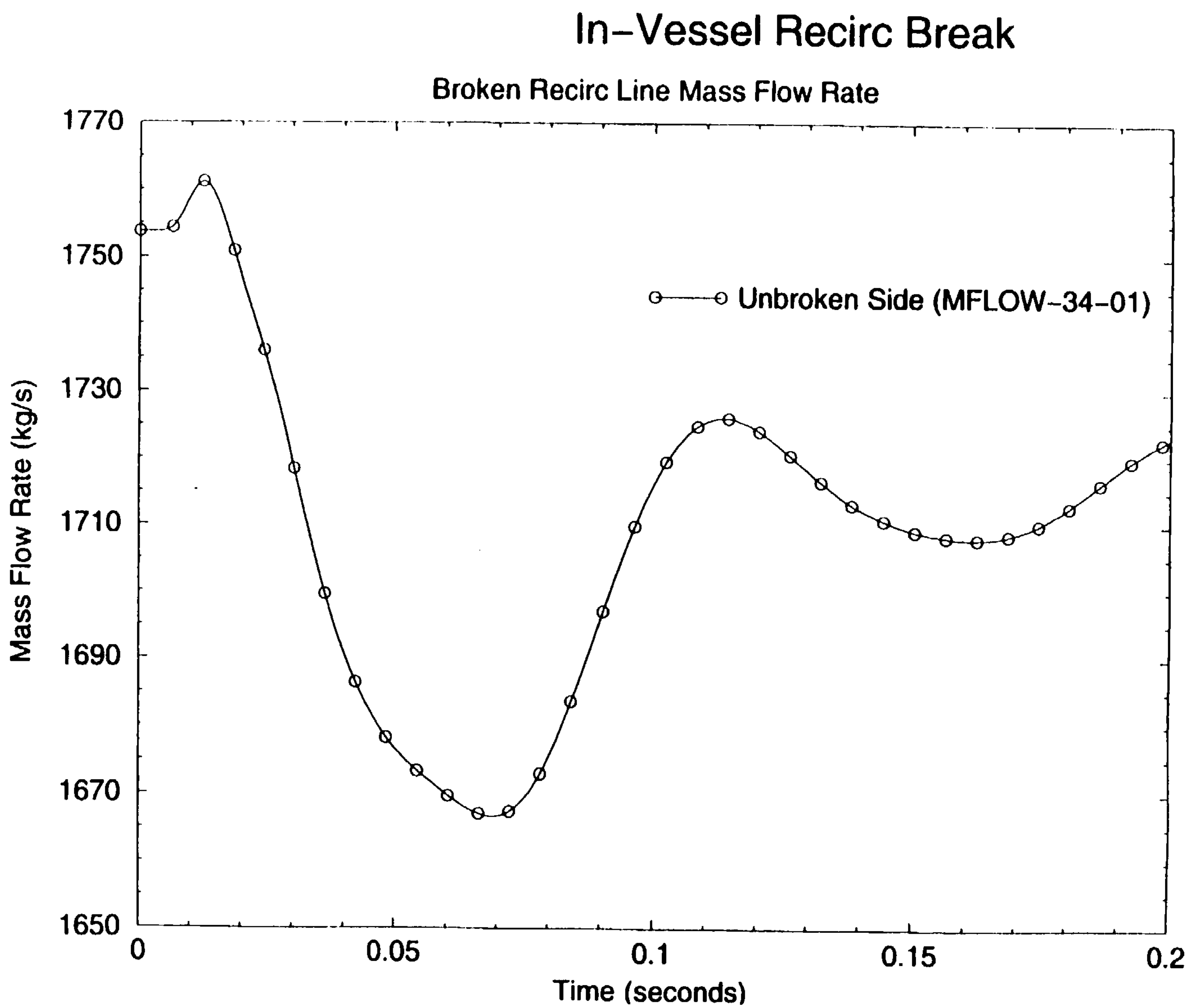


Figure 13: Mass Flow Rate in the Intact Side of the Recirculation Line (0-0.2 sec)

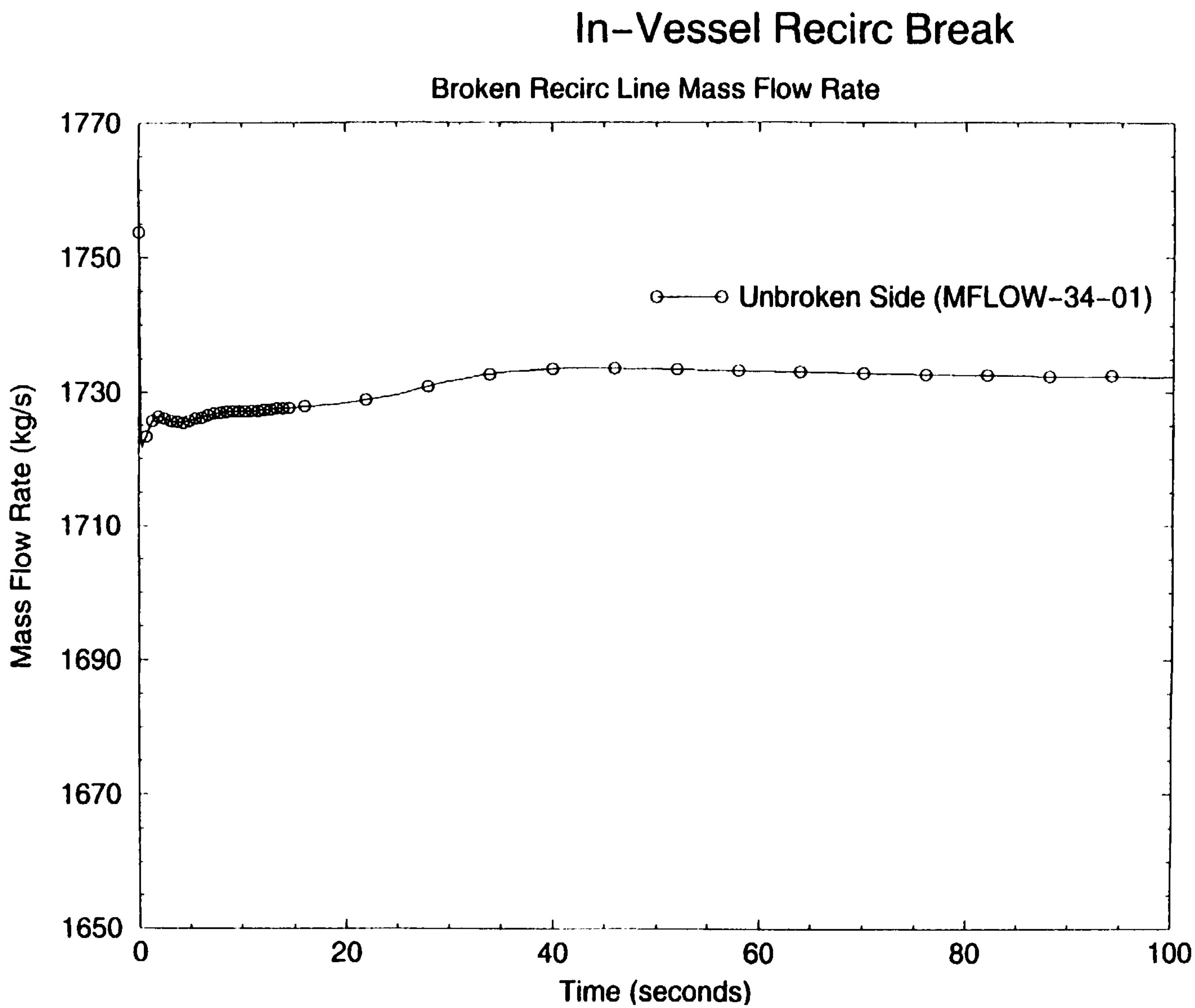


Figure 14: Mass Flow Rate in the Intact Side of the Recirculation Line (0-100 sec)

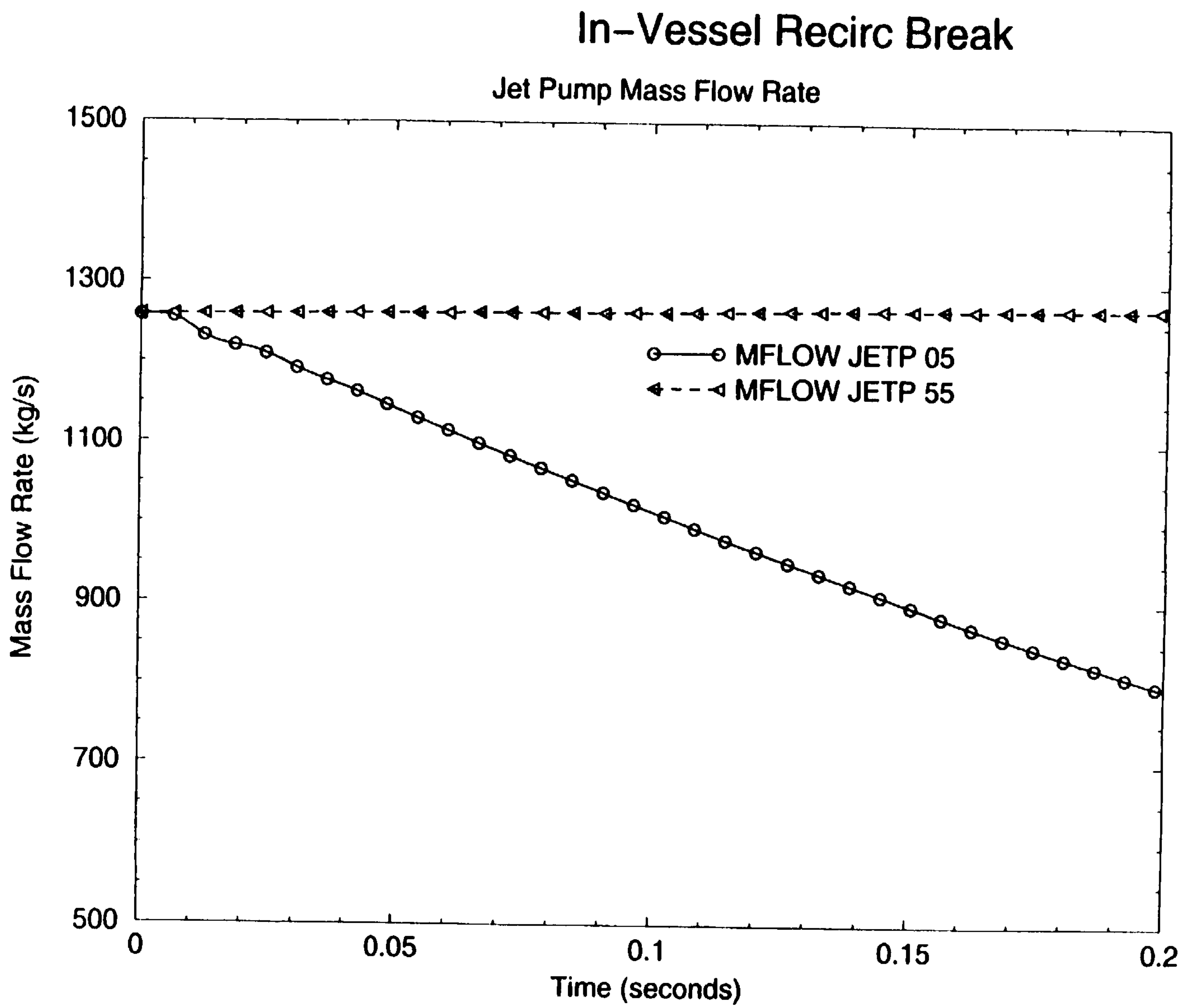


Figure 15: Mass Flow Rate in Jet Pump Components 5 and 55 (0-0.2 sec)

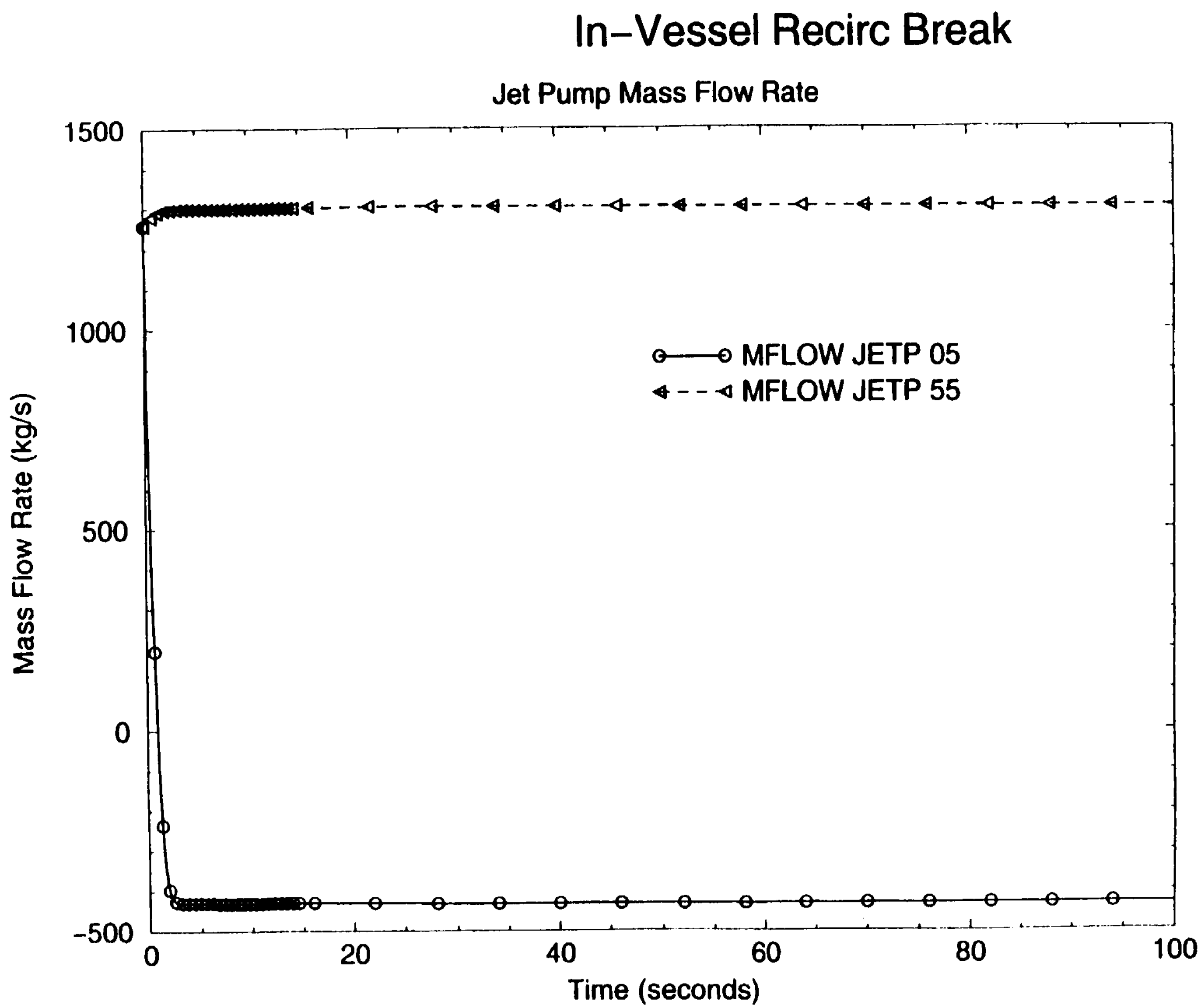


Figure 16: Mass Flow Rate in Jet Pump Components 5 and 55 (0-100 sec)

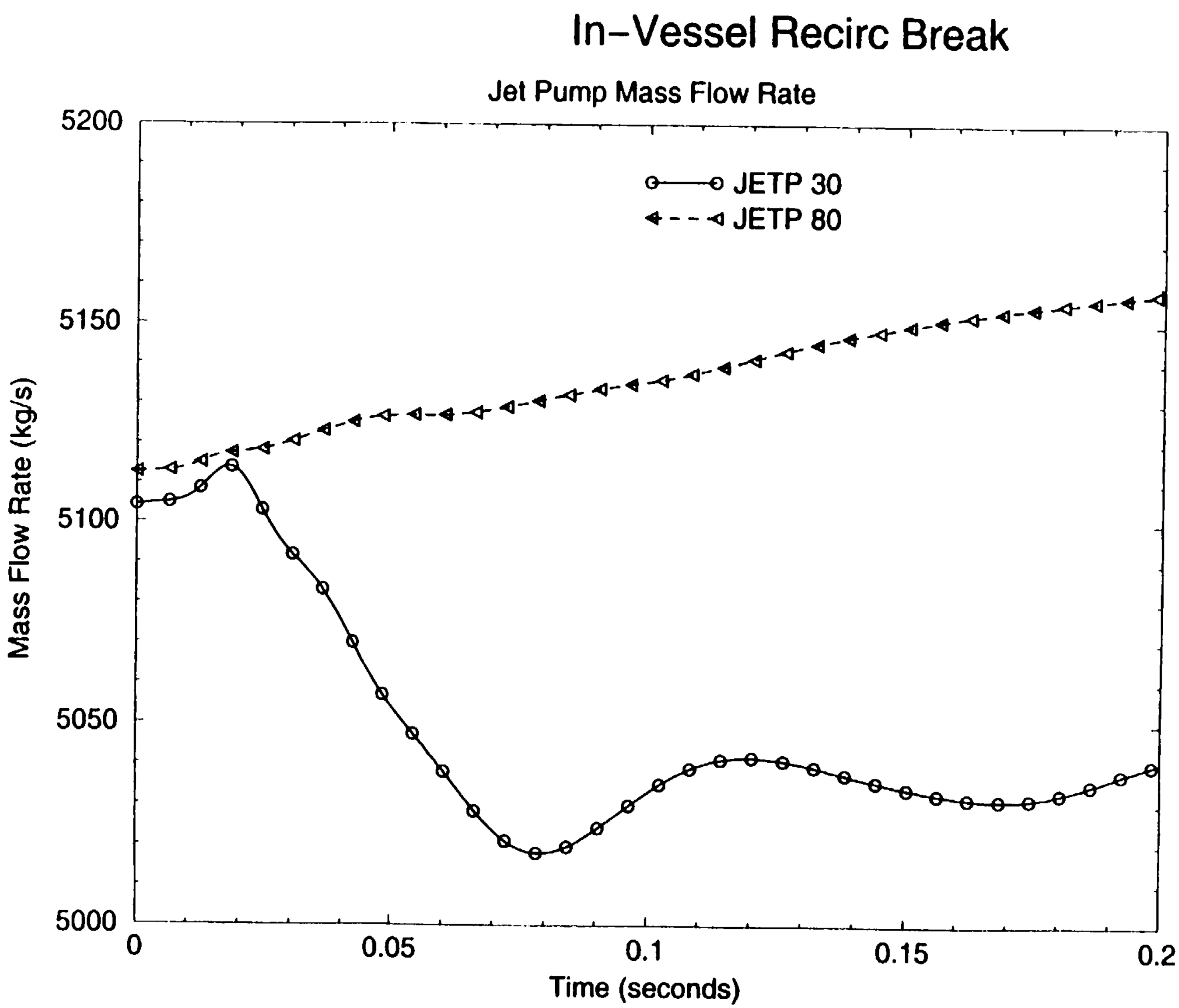


Figure 17: Mass Flow Rate in Jet Pump Components 30 and 80 (0-0.2 sec)

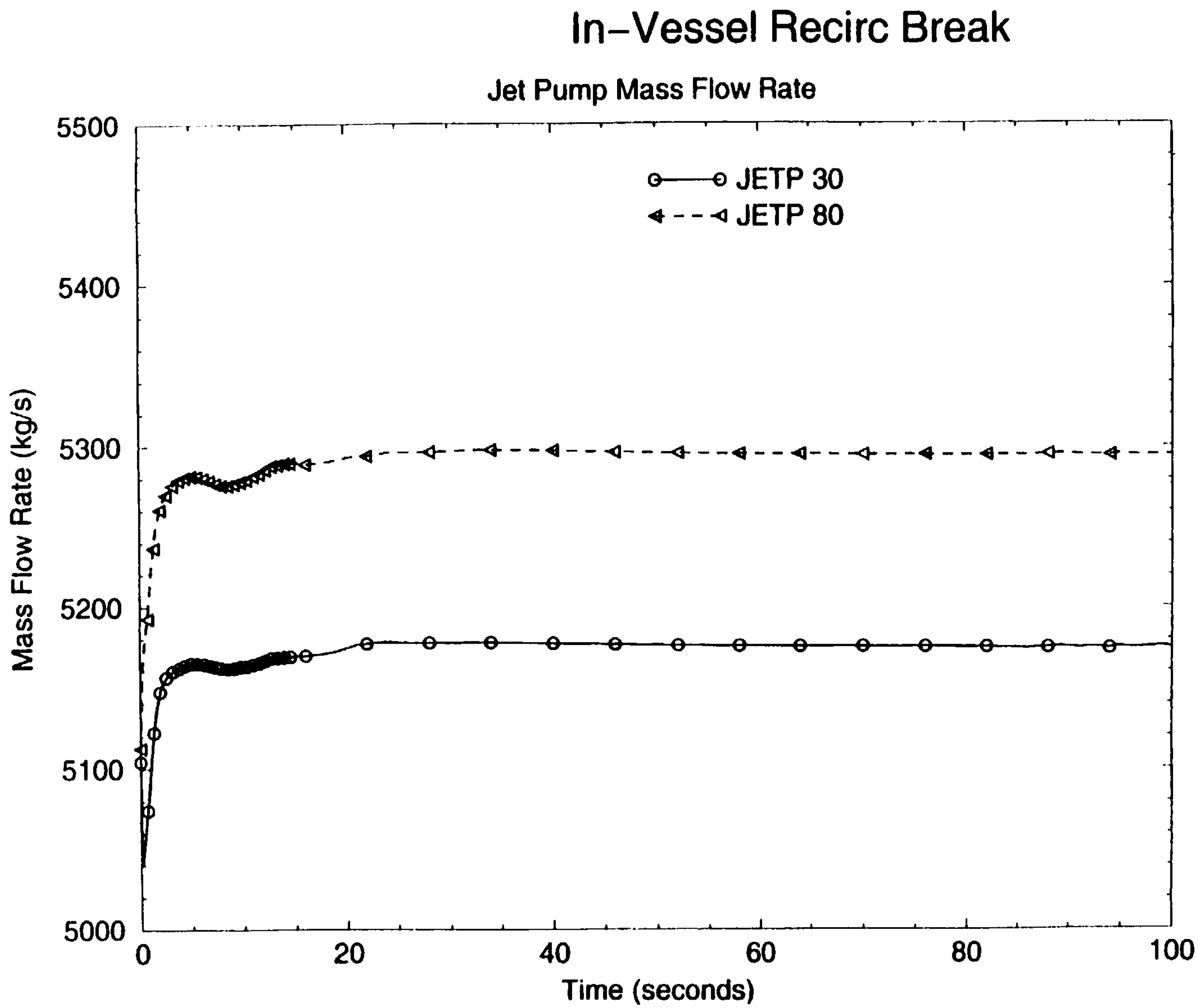


Figure 18: Mass Flow Rate in Jet Pump Components 30 and 80 (0-100 sec)

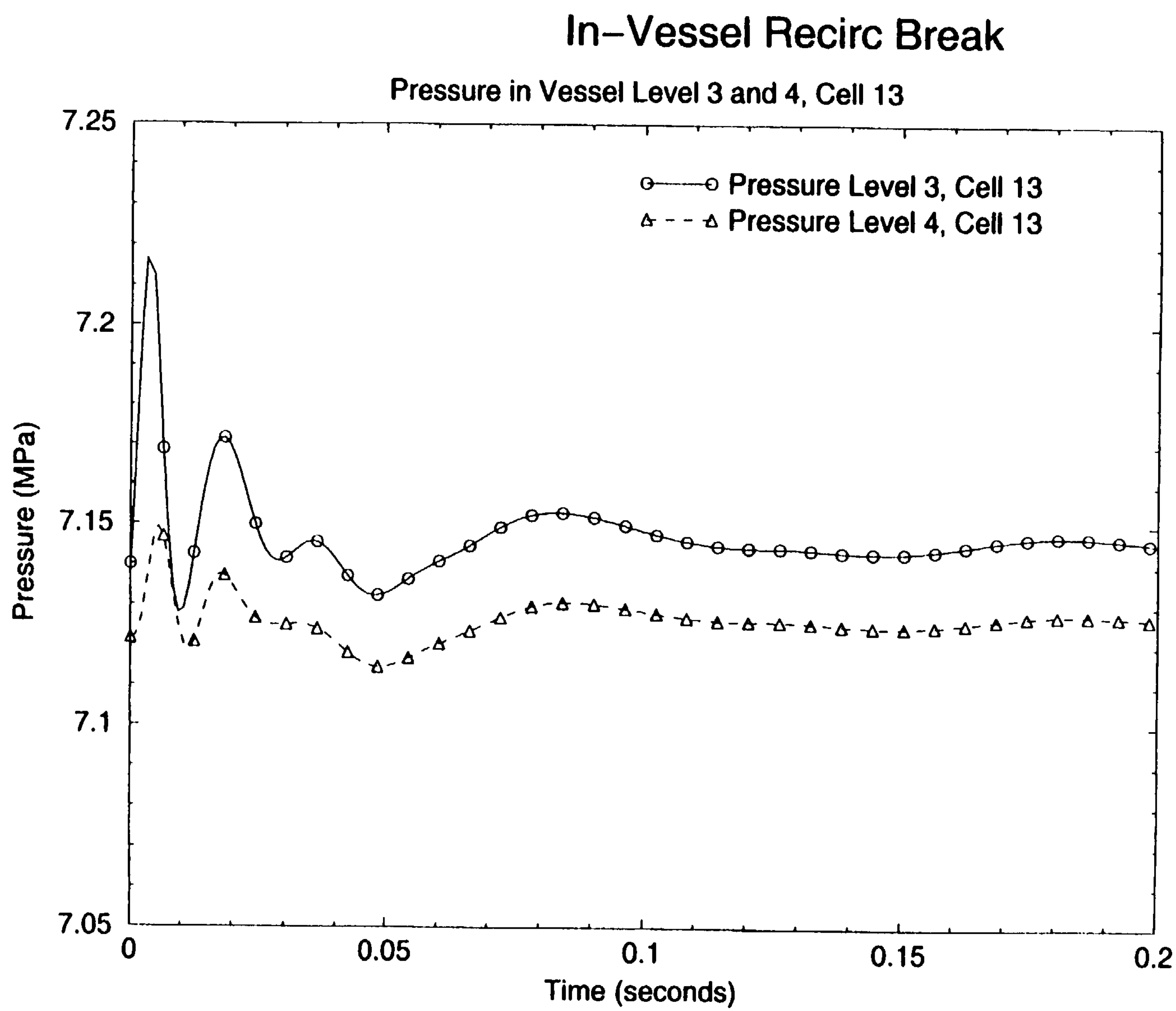


Figure 19: Pressure in Vessel Level 3, Cell 13, and Level 4 and Cell 13 (0-0.2 sec)

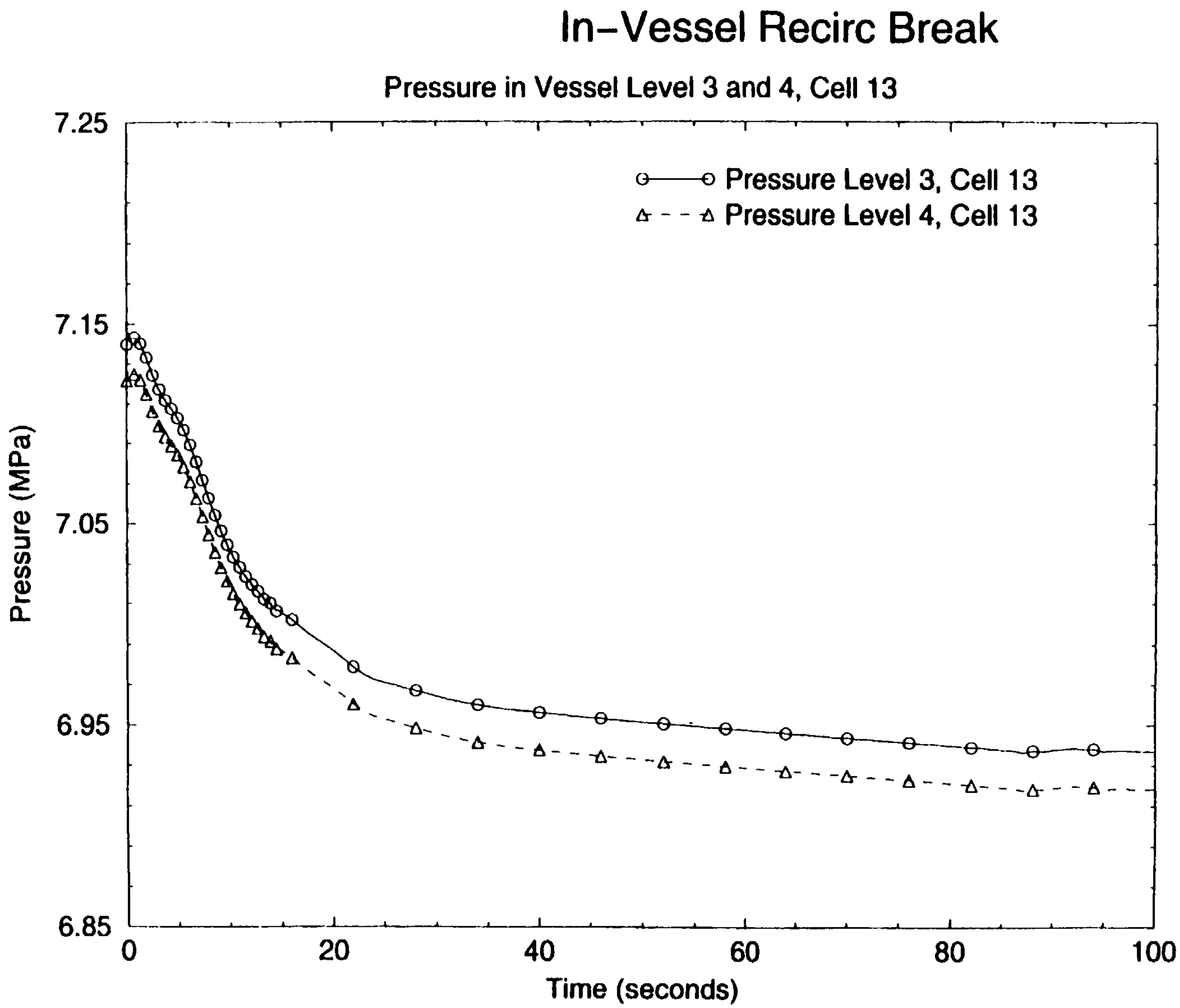


Figure 20: Pressure in Vessel Level 3, Cell 13, and Level 4 and Cell 13 (0-100 sec)

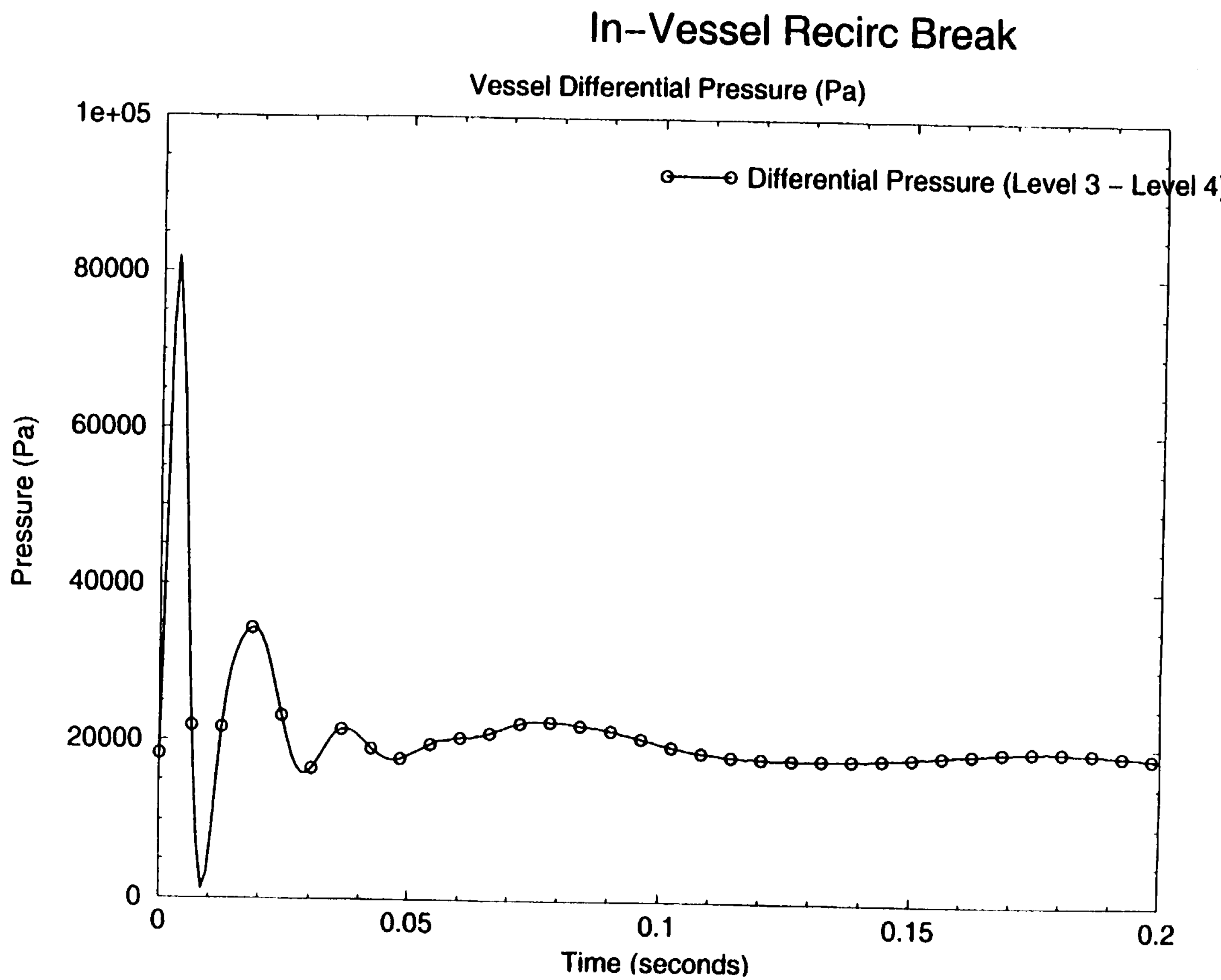


Figure 21: Differential Pressure Between Level 4 and 3 in Cell 13 (0-0.2 sec)

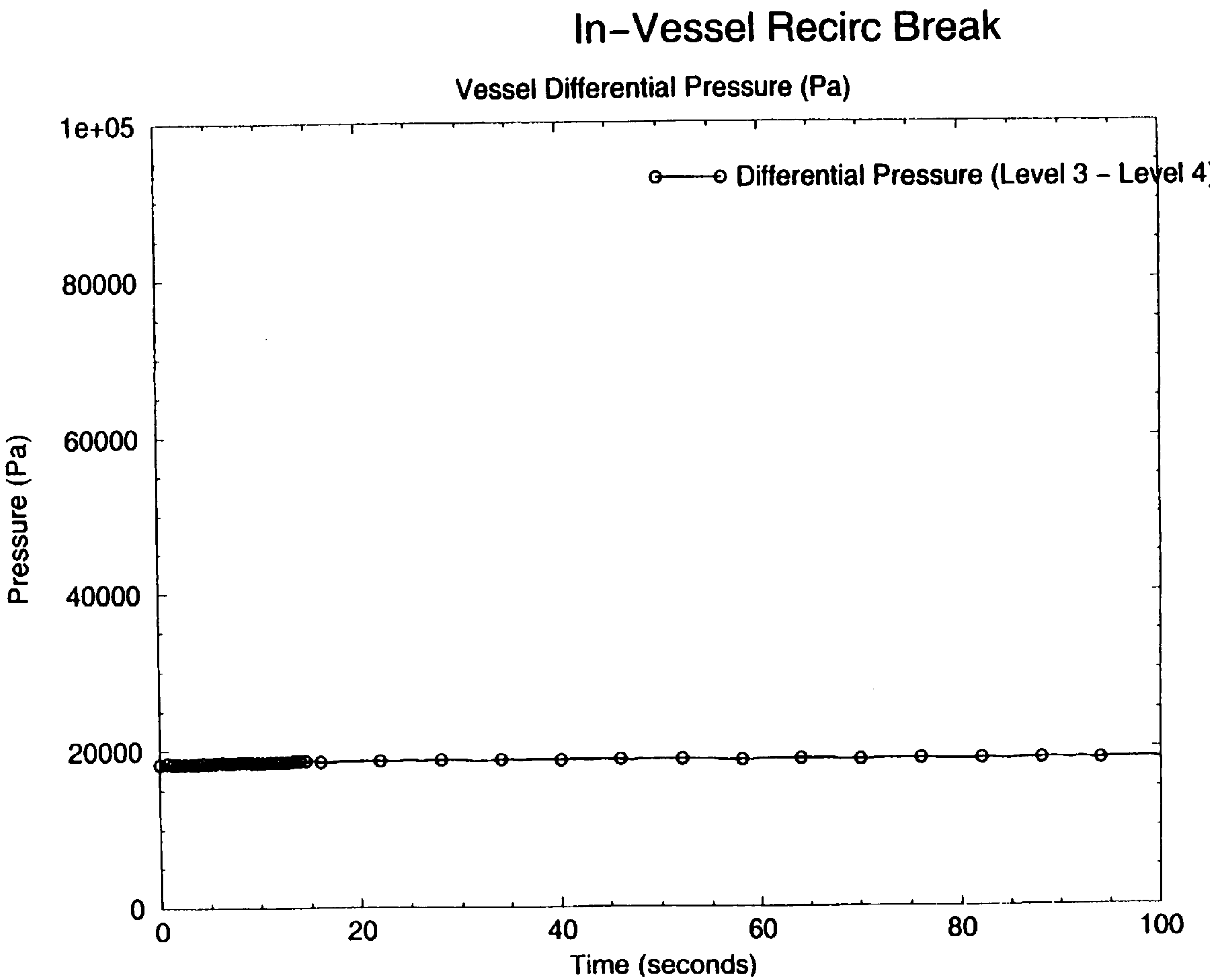


Figure 22: Differential Pressure Between Level 4 and 3 in Cell 13 (0-100 sec)

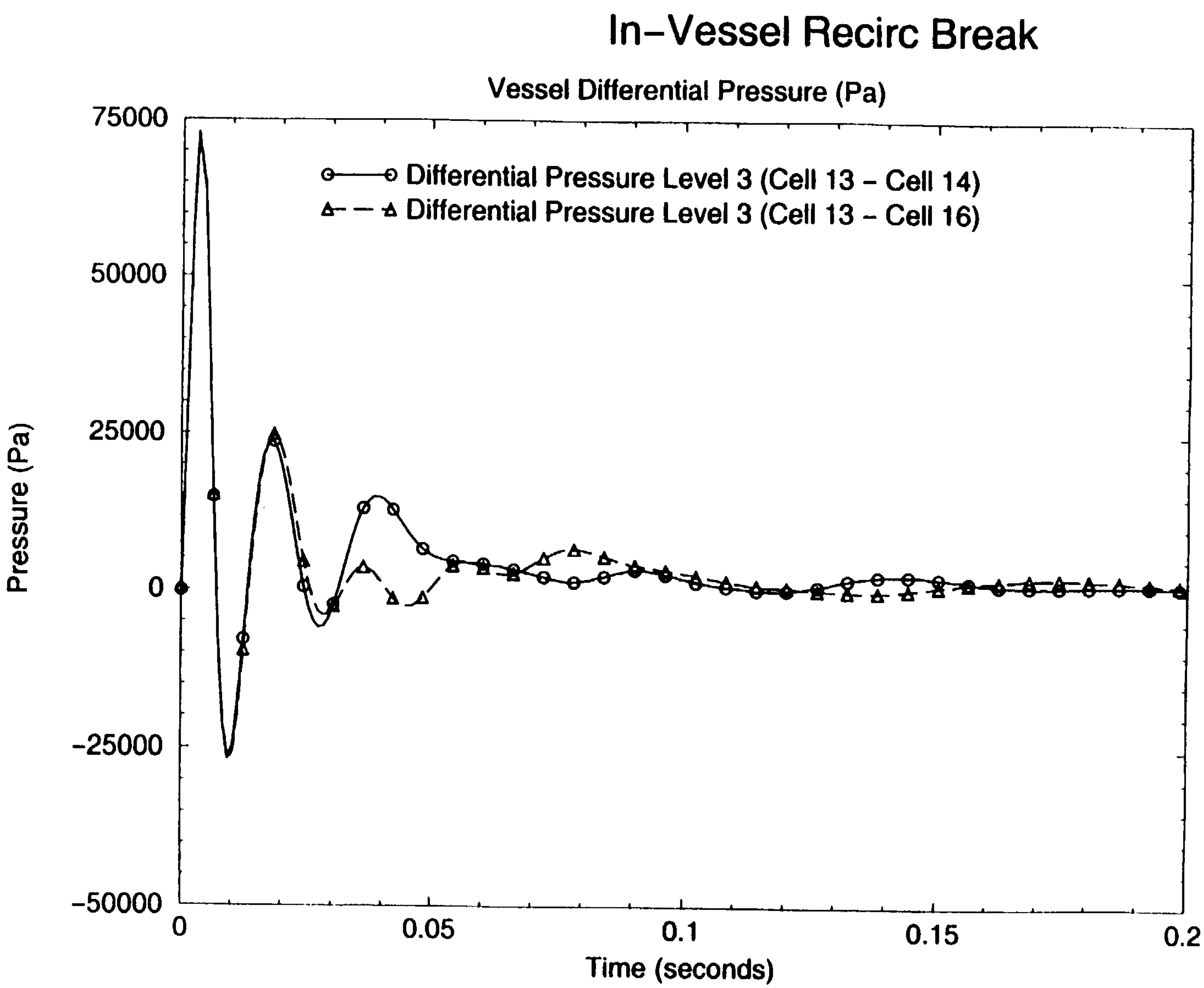


Figure 23: Differential Pressure Between Cell 13, 14 and 16 in Level 3 (0-0.2 sec)

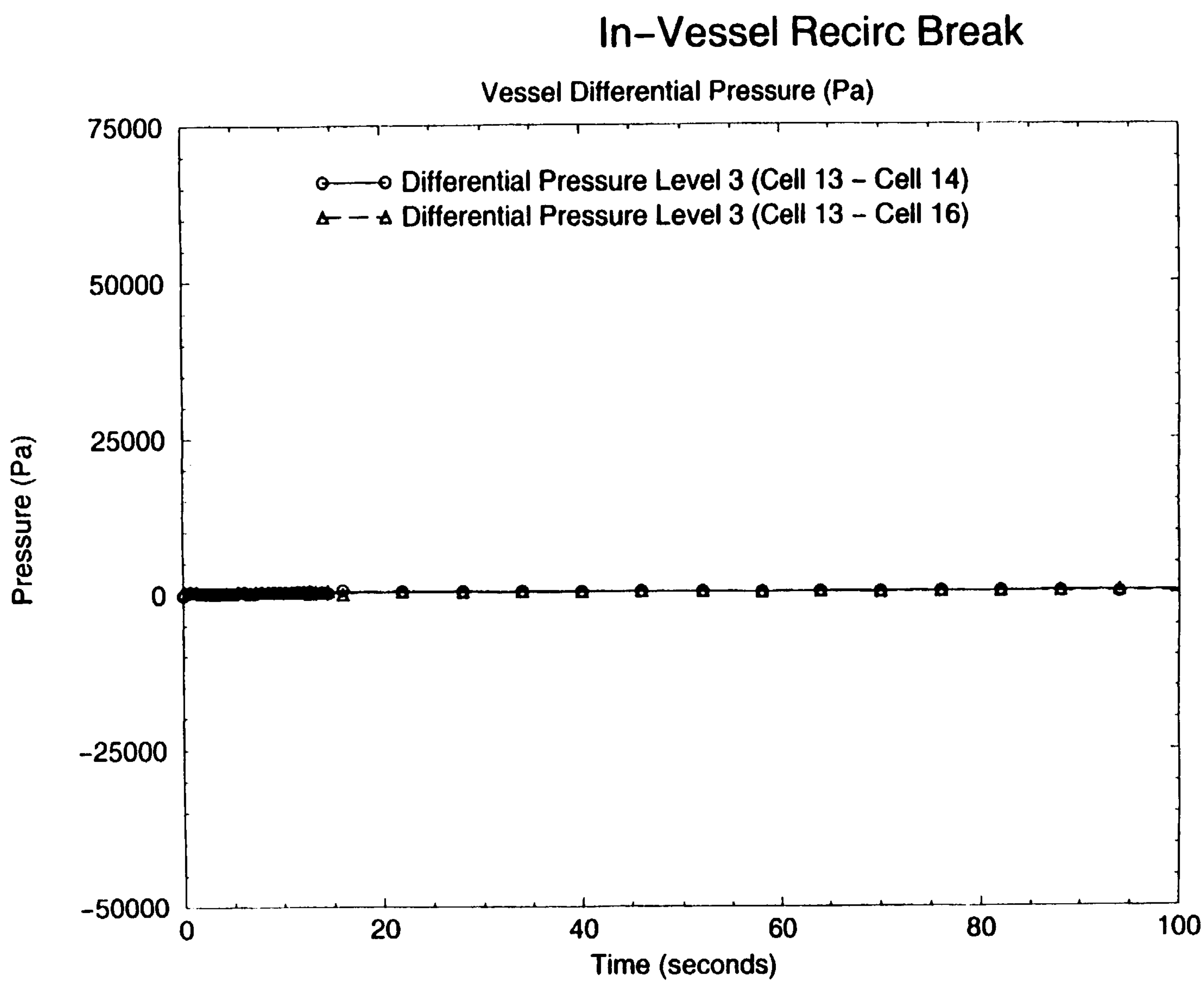


Figure 24: Differential Pressure Between Cell 13, 14 and 16 in Level 3 (0-100 sec)

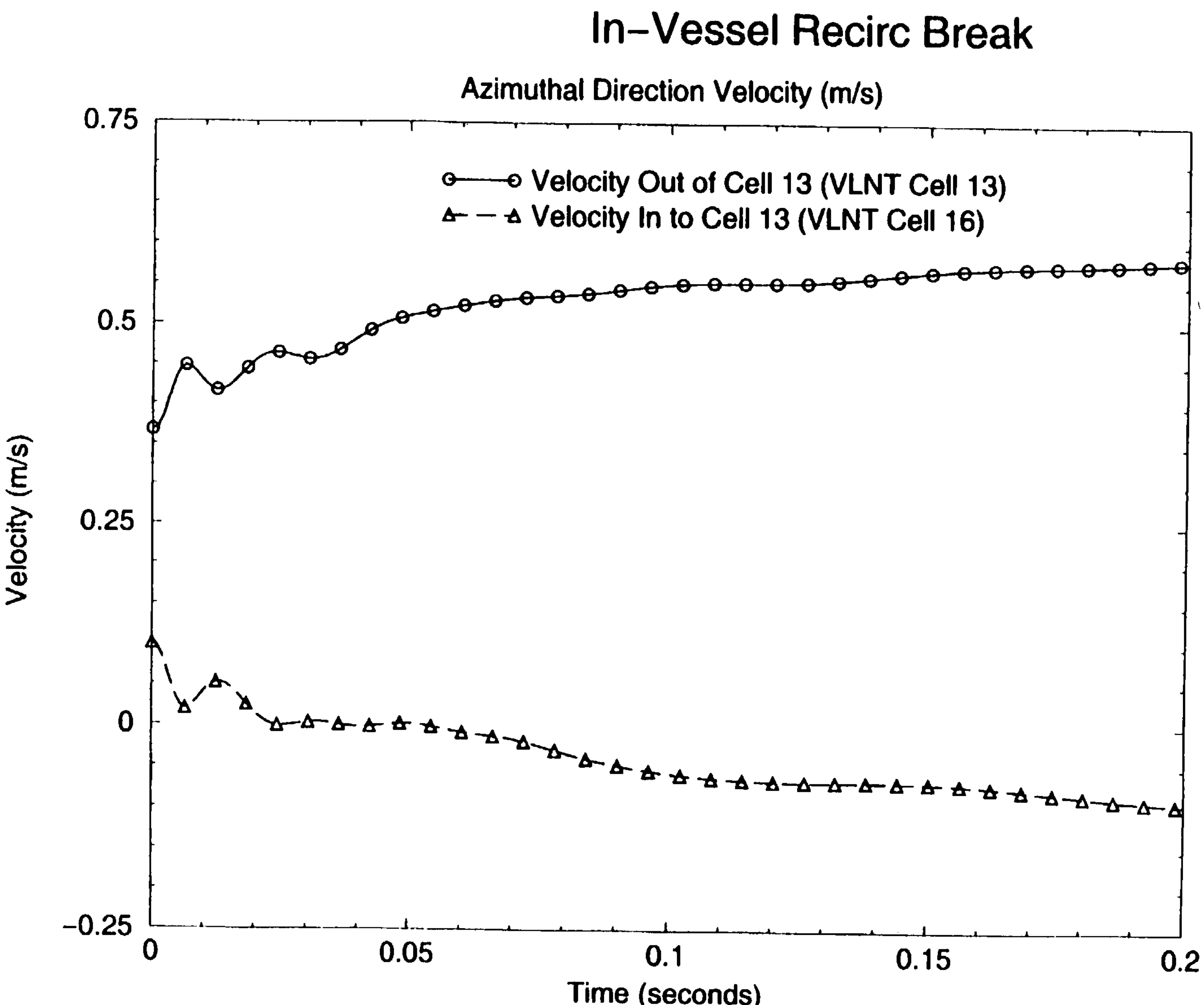


Figure 25: Azimuthal Liquid Velocities In And Out of Cell 13, Level 3 (0-0.2 sec)

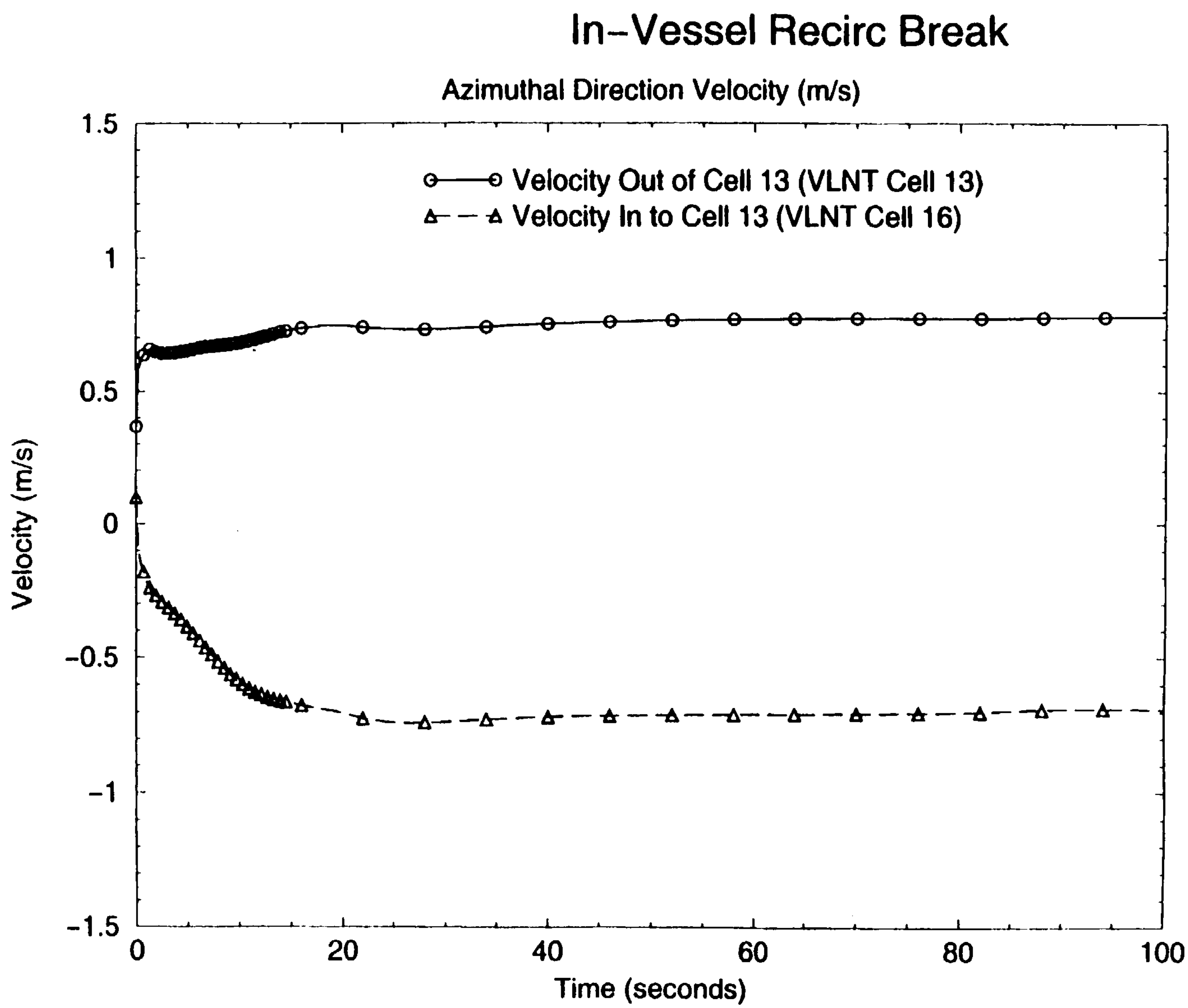


Figure 26: Azimuthal Liquid Velocities in And Out of Cell 13, Level 3 (0-100 sec)

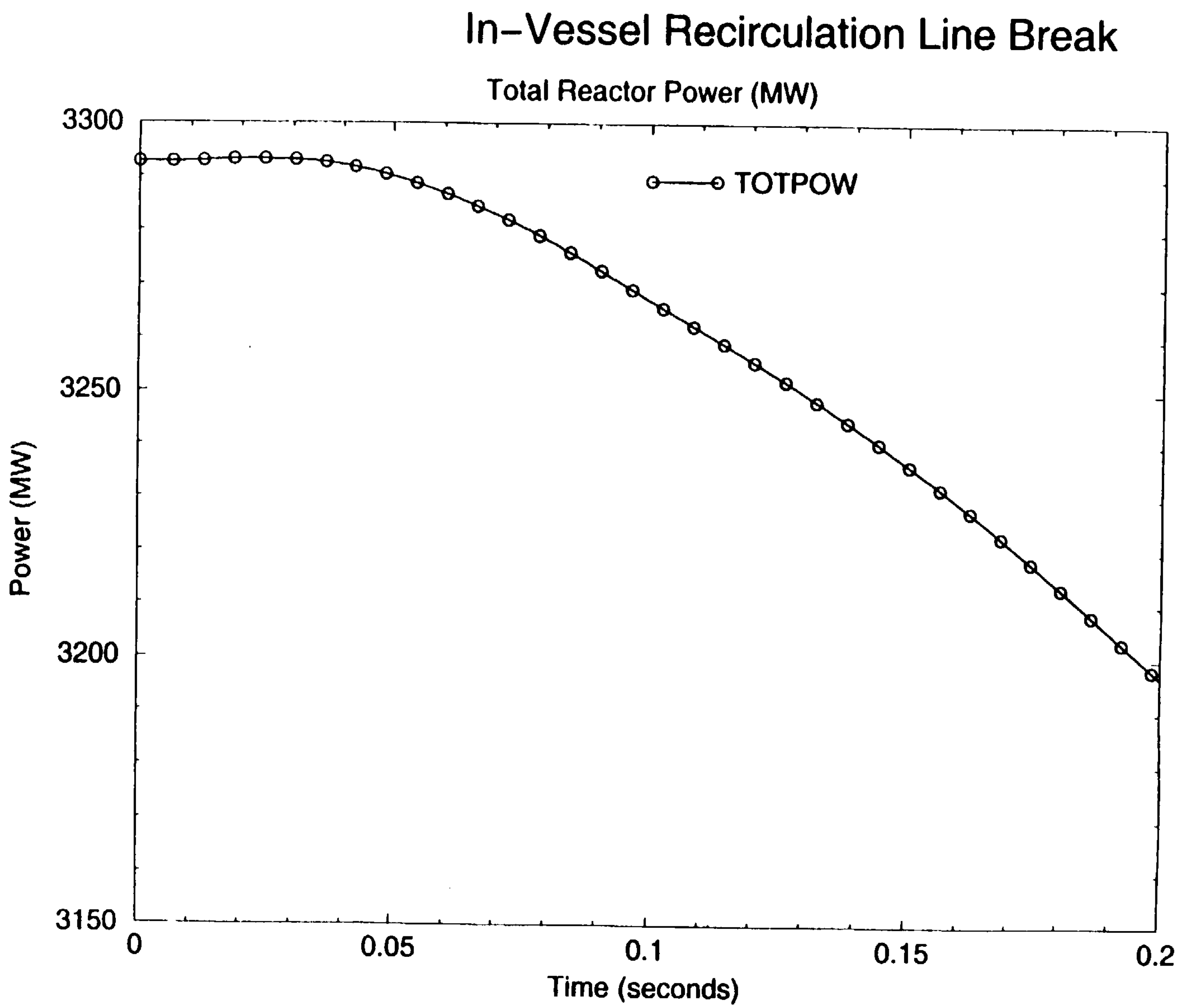


Figure 27: Total Reactor Power (0-0.2 sec)

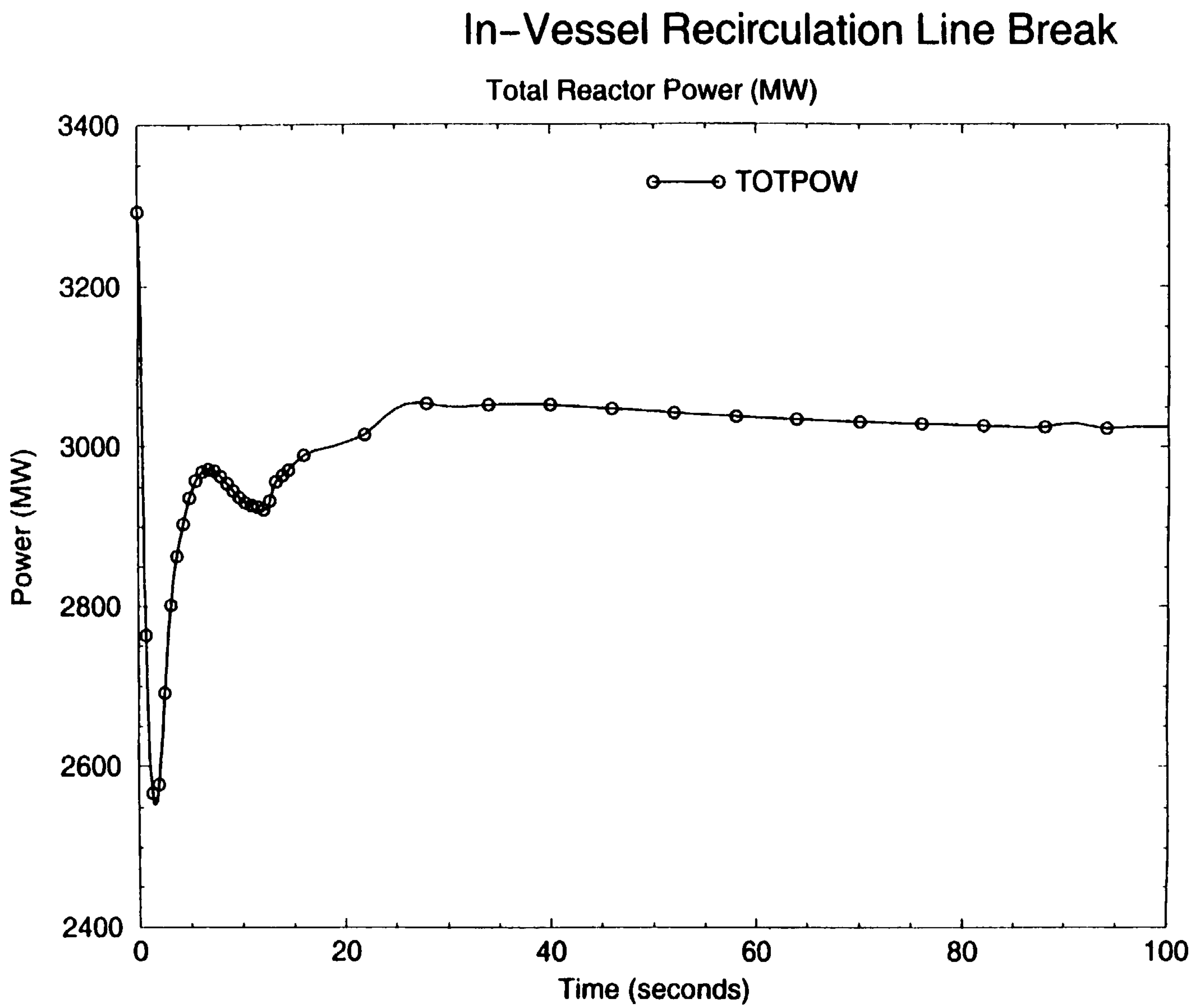


Figure 28: Total Reactor Power (0-100 sec)

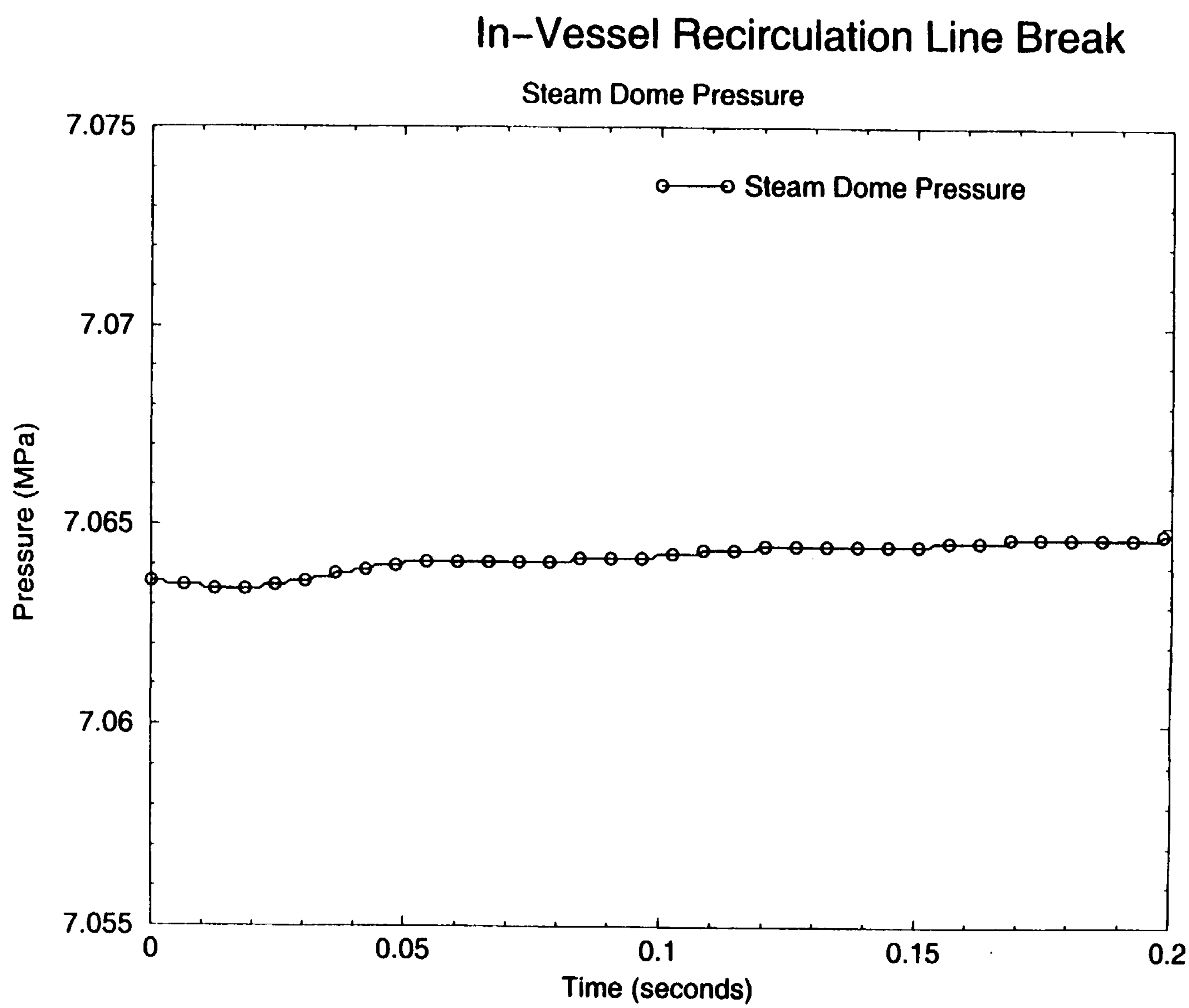


Figure 29: Steam Dome Pressure (0-0.2 sec)

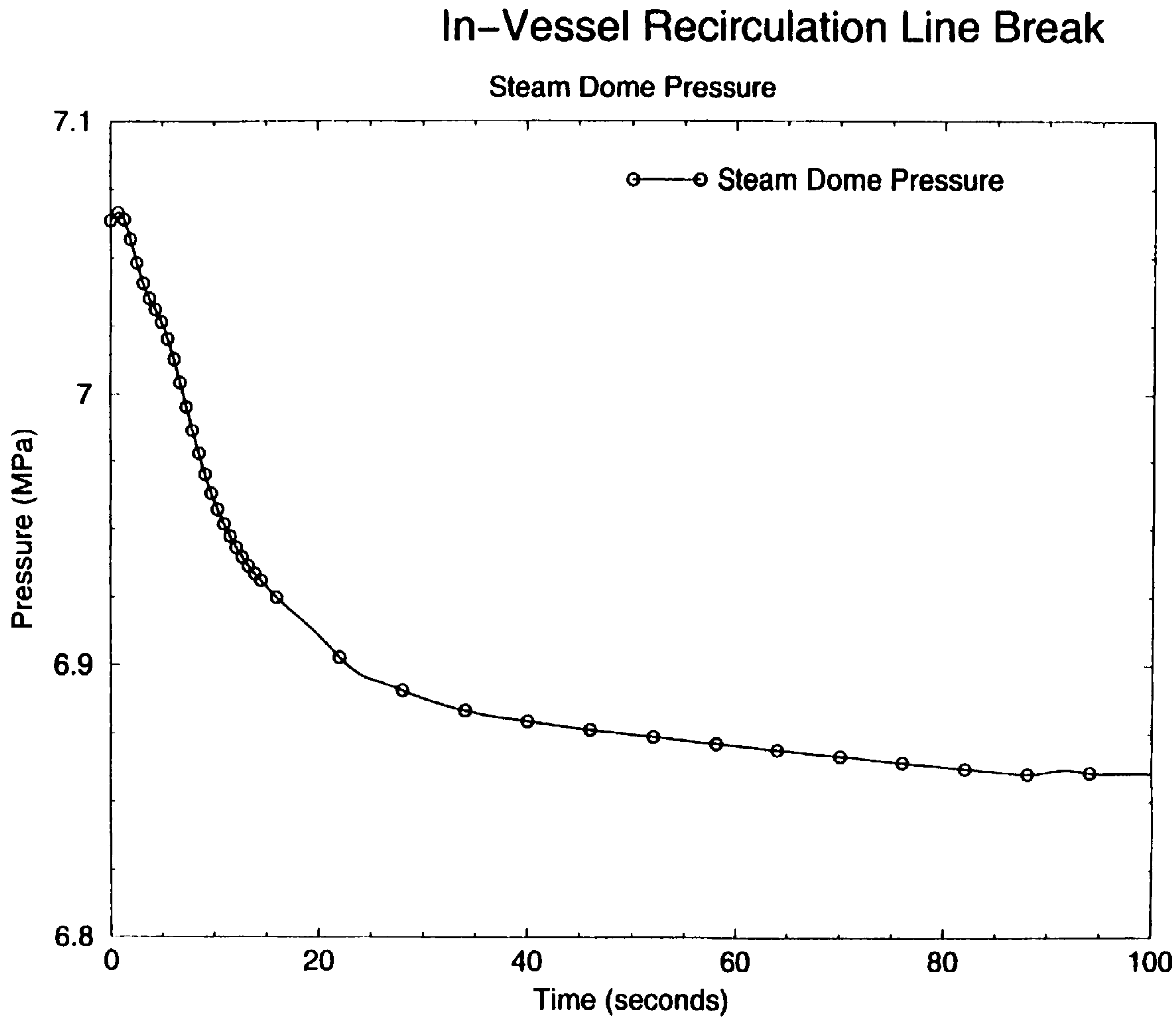


Figure 30: Steam Dome Pressure (0-100 sec)

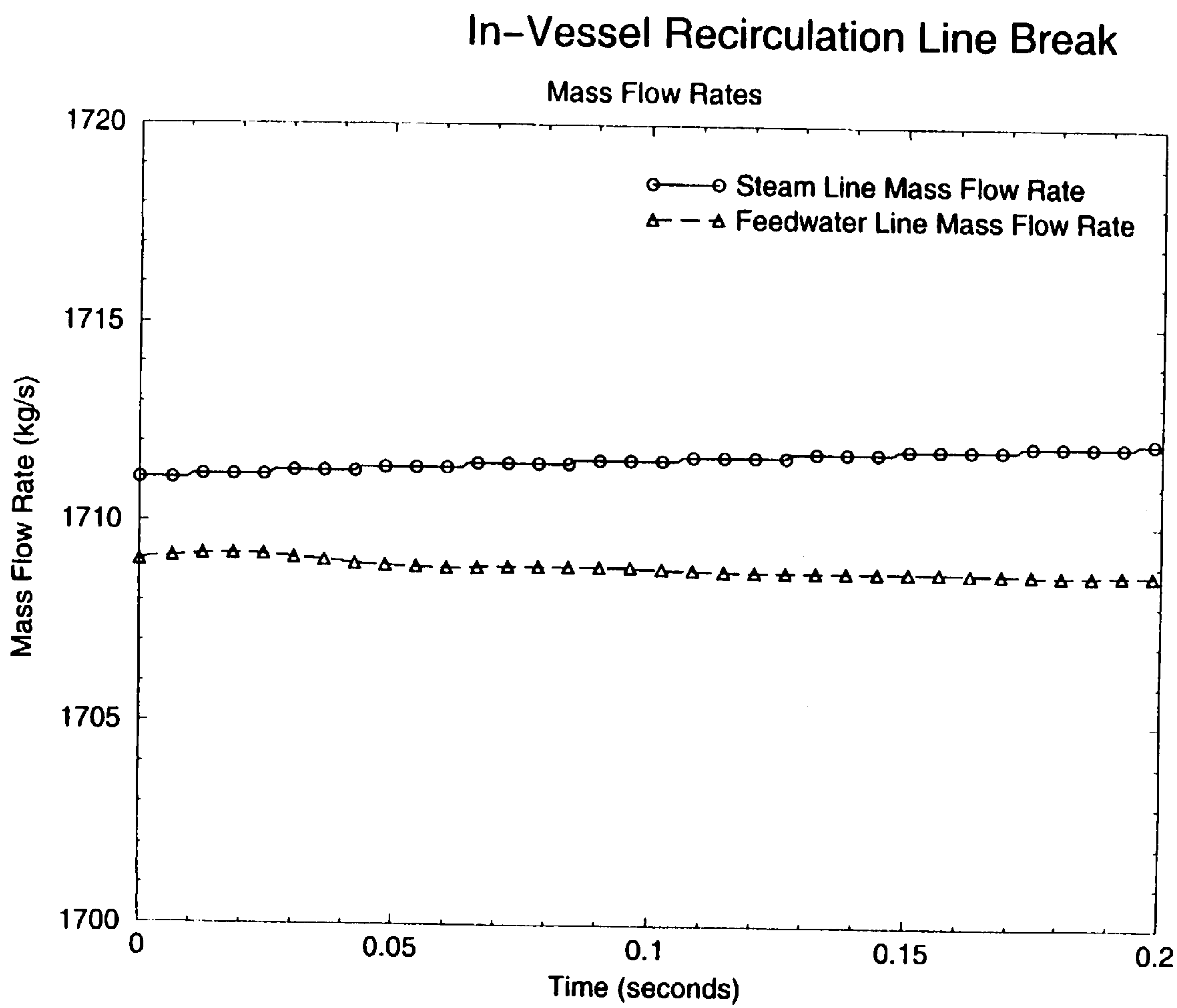


Figure 31: Steam Line and Feedwater Mass Flow Rates (0-0.2 sec)

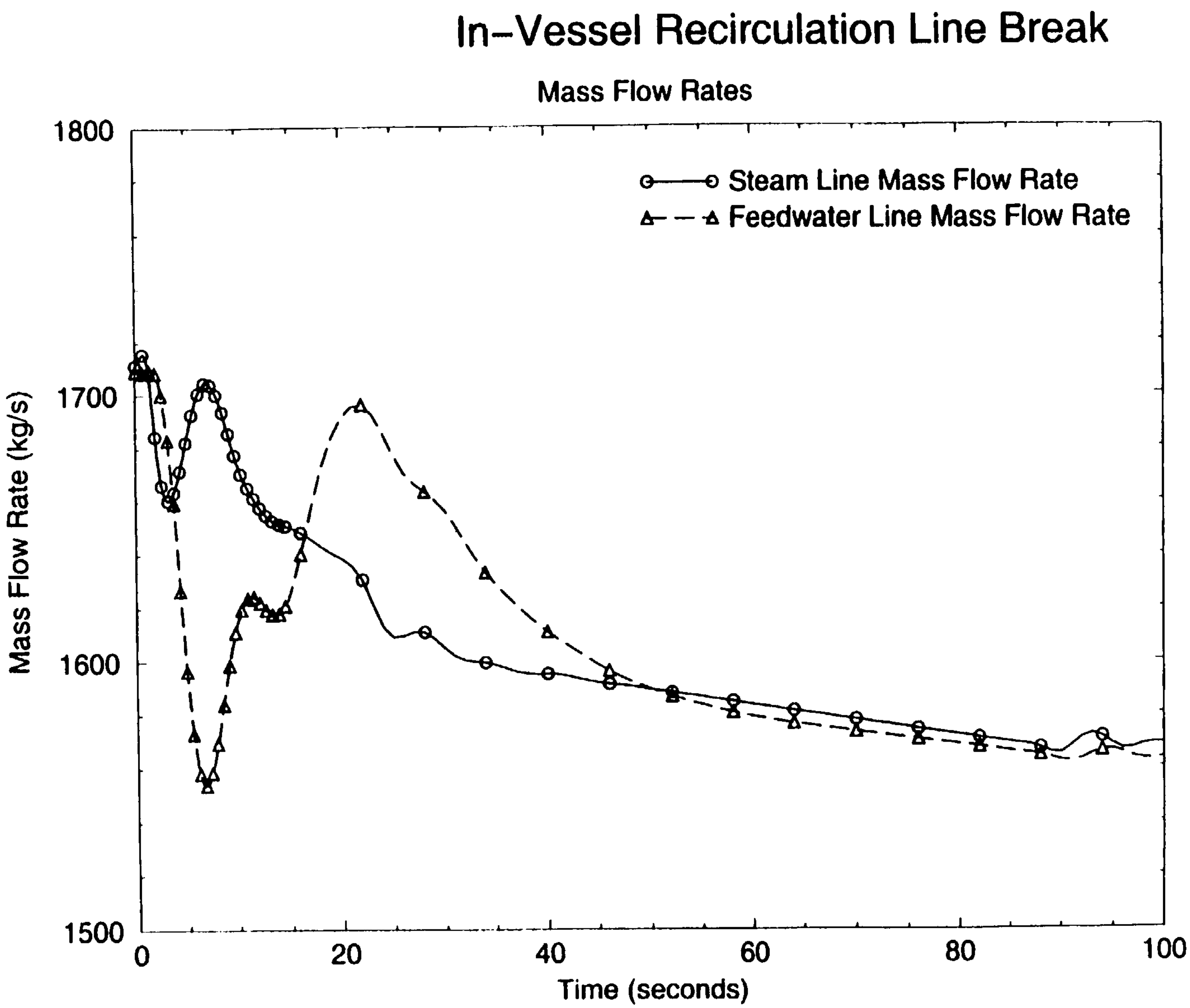


Figure 32: Steam Line and Feedwater Mass Flow Rates (0-100 sec)

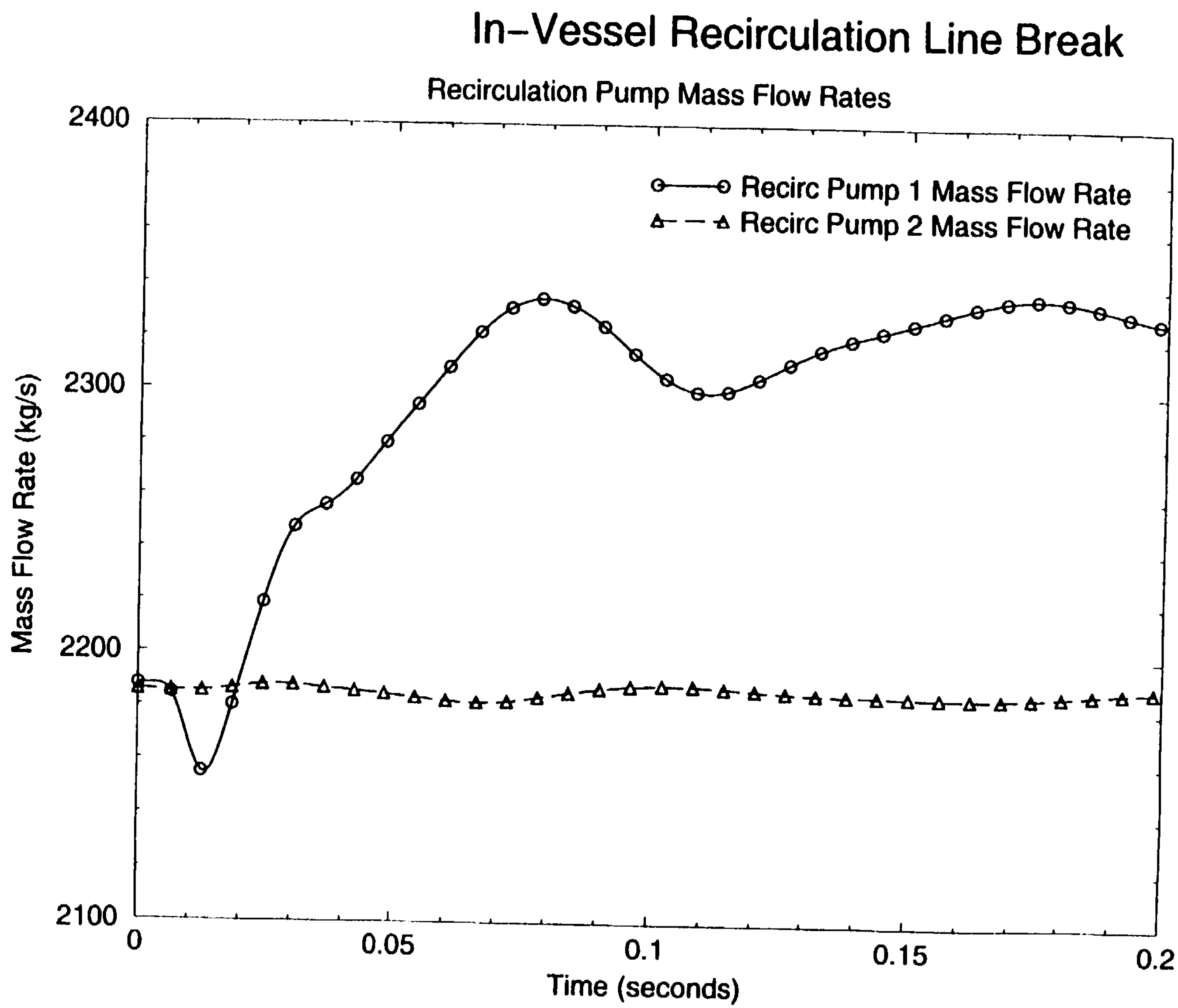


Figure 33: Recirculation Pump 1 and 2 Mass Flow Rates (0-0.2 sec)

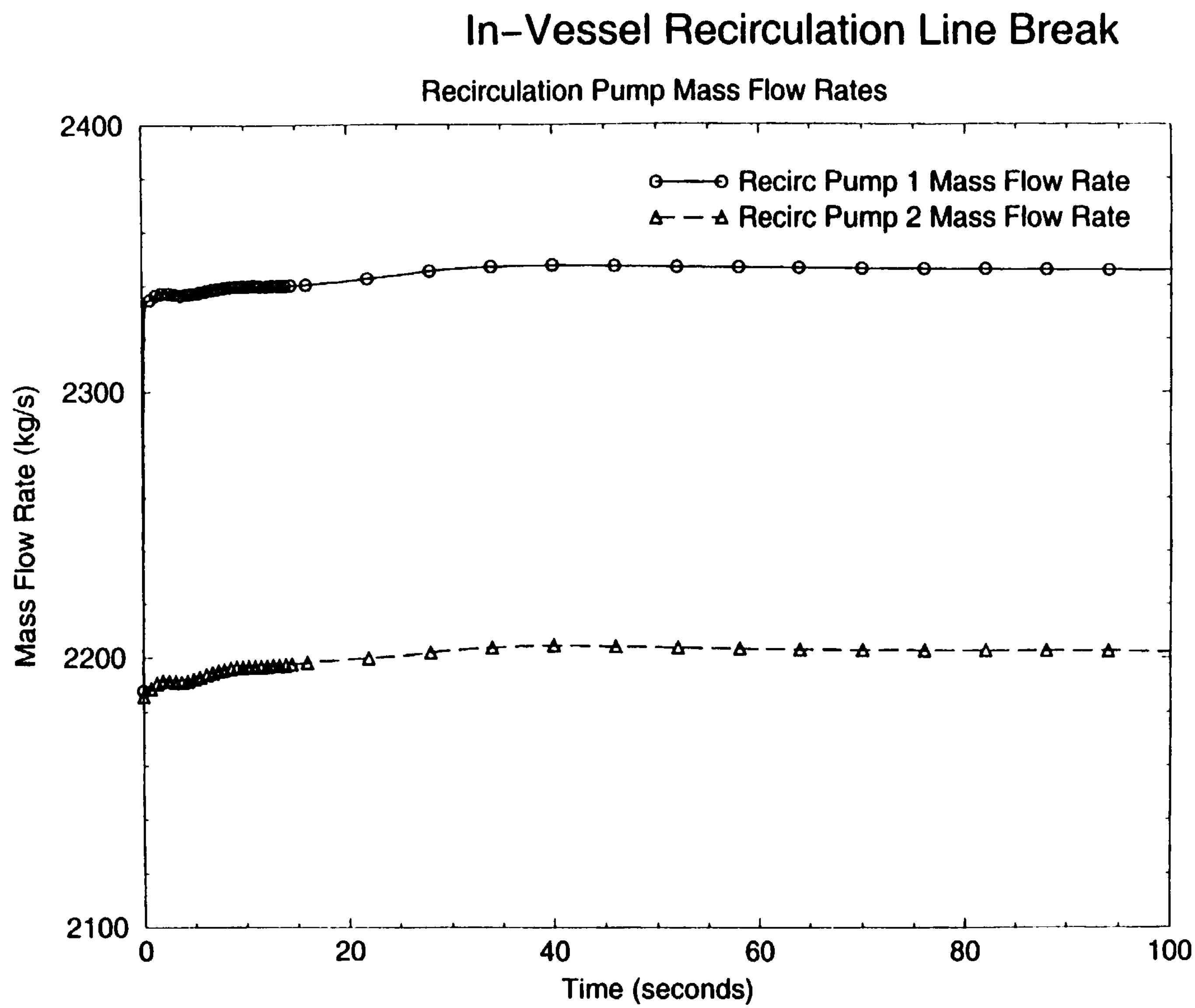


Figure 34: Recirculation Pump 1 and 2 Mass Flow Rates (0-100 sec)

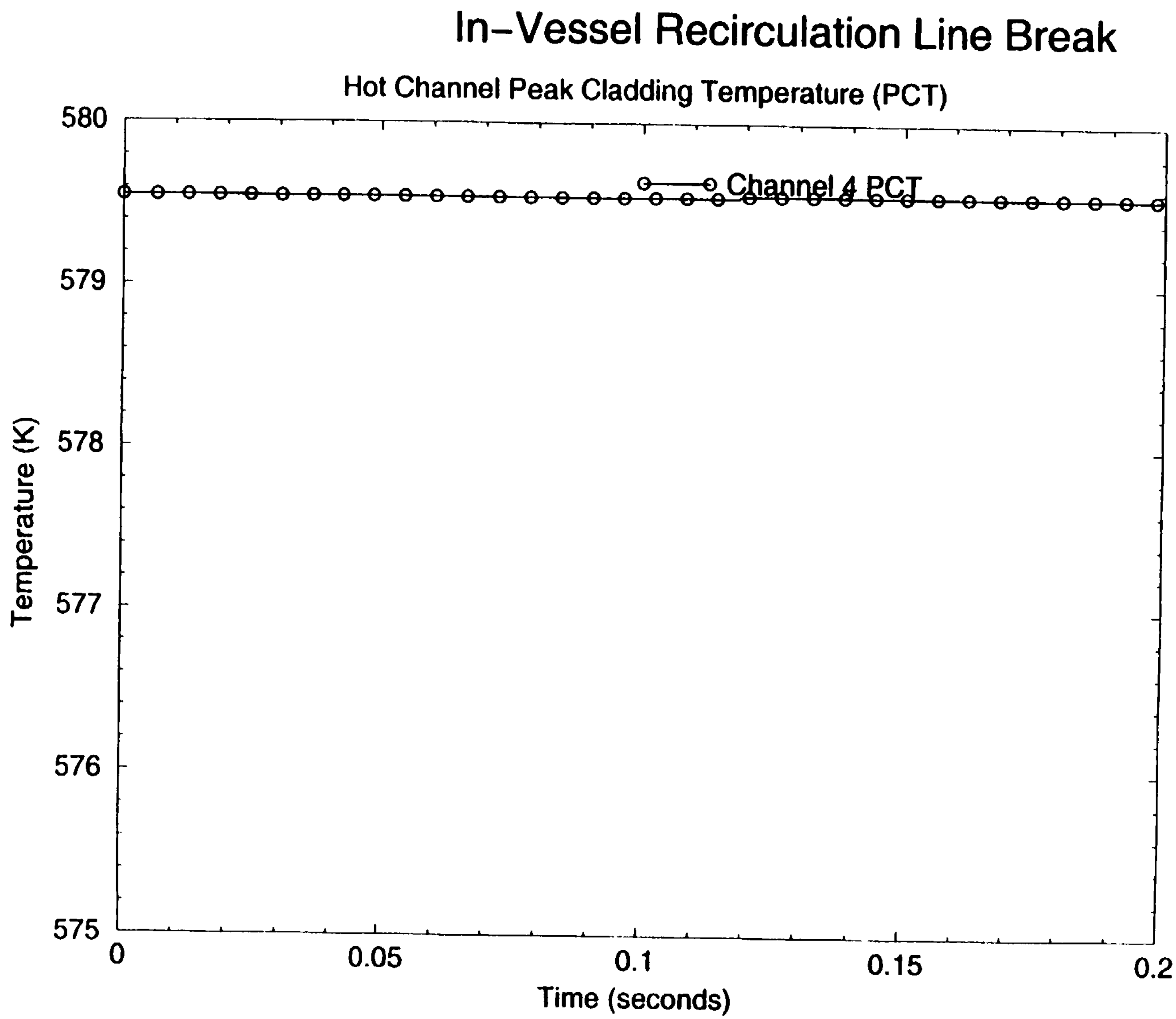


Figure 35: Peak Cladding Temperature for Hot Channel Component 4 (0-0.2 sec)

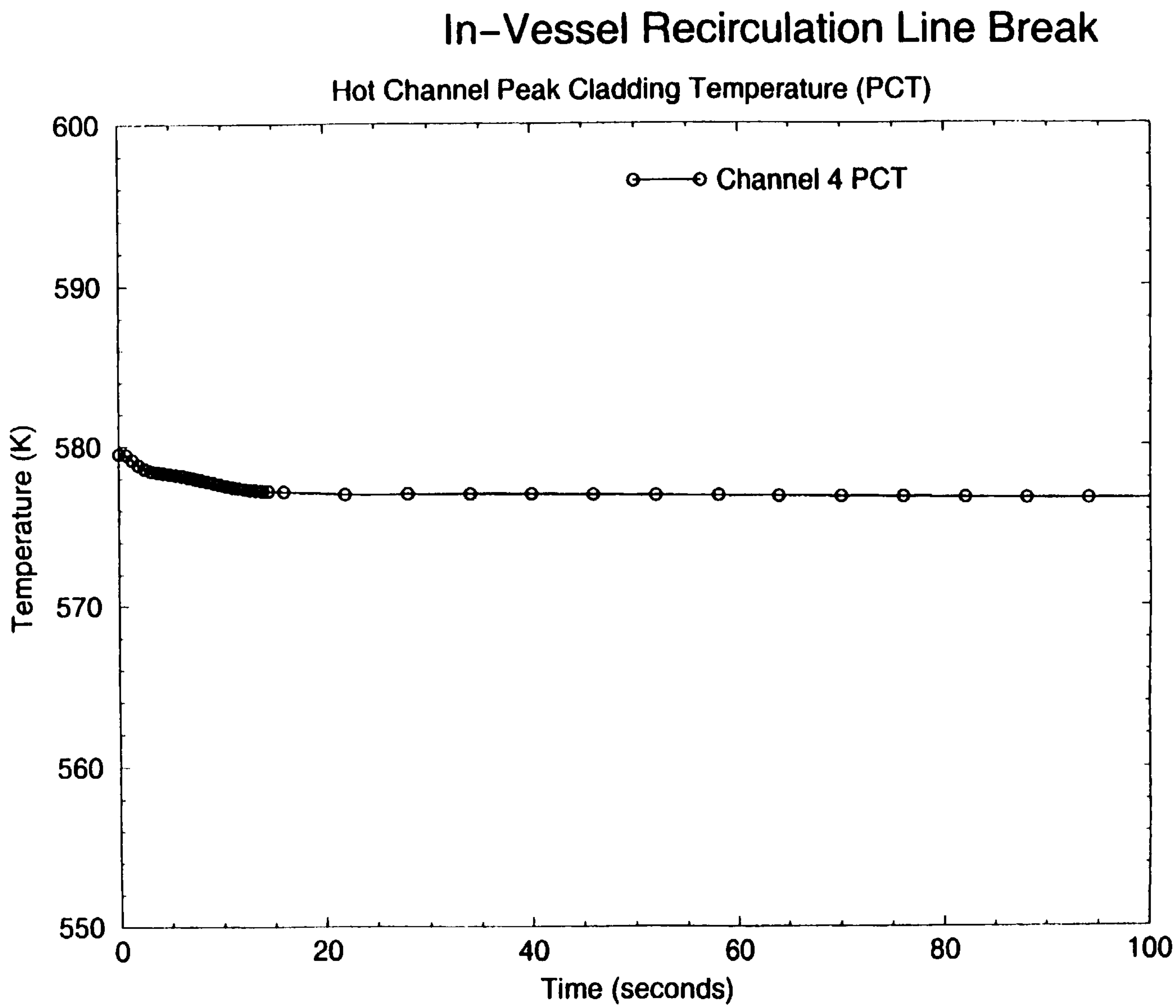


Figure 36: Peak Cladding Temperature for Hot Channel Component 4 (0-100 sec)

Feedwater Line Break Transient Calculation for

Christer Dahlgren and Don Fletcher

August 1998

SCIENTECH, Inc.
11140 Rockville Pike, Suite 500
Rockville, MD 20852

INTRODUCTION

This calculation was performed as part of the support of the BWR component failure program. The purpose of this calculation is to provide thermal and hydraulic information to support the assessment of failure of the feedwater line. The assessment of BWR component failure is to be conducted by the INEEL.

The break was postulated to occur in the common part of the feedwater line that connects the three feedwater spargers on one side of the vessel (see Figure 1). The break is assumed to occur during normal operation. The break in the feedwater line will cause liquid and steam to exit the vessel component through the spargers. The spargers are shaped like a circular 60° segment, with a diameter of 10 and contain several holes (Figure 2). Figure 3 presents the nodalization which was utilized to calculate the break response.

One important parameter is the flow resistance of the break. The flow resistance in the break junction consists of several components, of which the most important is the flow area change between the orifices in the sparger and the vessel cell. The value of the flow resistance was calculated to be 26.2 [Reference 3].

The purpose of this calculation is to provide the boundary conditions for failure assessments of the affected components.

The following parameters are presented in Figures 4 to 34:

Break Parameters:
Mass Flow Rate in the broken feedwater line (Figure 4 and 5)
Liquid Velocity in the broken feedwater line (Figure 6 and 7)
Upstream Break Pressure (Figure 8 and 9)
Upstream Break Temperature (Figure 10 and 11)
Upstream Break Void Fraction (Figure 12 and 13)
Upstream Break Density (Figure 14 and 15)

System Parameters:
Total Reactor Power (Figure 16 and 17)
Steam Dome Pressure (Figure 18 and 19)
Steam Line and Feedwater Mass Flow Rates (Figure 20 and 21)
Steam Relief Valve Mass Flow Rate (Figure 22)
Recirculation Pump 1 and 2 Mass Flow Rates (Figure 23 and 24)
Mass Flow Rate in jet pump components 5 and 55 (Figure 25 and 26)
Mass Flow Rate in jet pump component 30 and 80 (Figure 27 and 28)
Peak Cladding Temperature for Hot Channel Component 4 (Figure 29 and 30)

Vessel Parameters (Time Scale Only 0.0-0.2 sec):

Pressure in Level 7 and 8 (Figure 31)
Differential Pressure Between Level 7 and 8 (Figure 32)
Differential Pressure Level 7, cell 13, 14 and 15 (Figure 33)
Azimuthal Direction Vessel Velocities, Level 7 (Figure 34)

All break and system parameters have been plotted with two different time scales, 0.0-0.2 sec, and 0-200 sec. The shorter time scale was included to show the details of the initial transient behavior for the break parameters. The larger time scale shows the system properties reaching a quasi-steady operational state after the break opened which differed from the initial steady state. The first 0.20 sec of the transient was calculated using a time step of 0.001 sec. This time step was based on the sonic courant limit for the cell upstream of the break location. The courant limit for this cell is:

$$\Delta x/u_{sonic} = 1.16/1100 \text{ sec} = 0.00105 \text{ sec}$$

This time step was necessary to capture the decrease in pressure in the recirculation line. Every calculated time step is plotted, but for reasons of clarity, a symbol is only attached to every fifth data point.

The remainder of the transient was calculated using a maximum time step of 0.01 sec. The courant limit was much lower than that after the relief valves opened. The courant limit for the major part of the calculation was 0.0015 sec. The courant limit time step was limited by component 61, which represents the bypass valves.

The results of this calculation are presented below in the discussion section. A summary of the results and concluding remarks are presented in the conclusion section.

DISCUSSION

This section discusses the results of the calculation and the changes in the key parameters during this transient.

Figures 1 to 3 (attached) show simplified diagrams of the break location, detailed drawings of the sparger components, and a nodalization diagram of the break components.

A timing of key events for the feedwater line break is given in Table 1. These events include MSIV closure, SCRAM, recirculation line pump coast down, LPCI and LPCS injection etc.

A summary of the key break and vessel parameters follows in the conclusion section. The key parameters are presented in Figures 4 to 34.

Table 1: Events Timetable for the Feedwater Line Break.

Event	Time after break [s]
MSIV Closure	5
Steam Line Pressure Relief Valves Open (ADS Function)	7
SCRAM	8
Recirculation Pump Trip	3
Low Downcomer Liquid Level Trip	9
Low-low Downcomer Liquid Level Trip	19
LPCI, LPCS Injection	>100 (not yet)

CONCLUSIONS

The feedwater line break analysis was performed in the support of the BWR component failure program. The key parameter responses for this transient calculation are identified below:

Break Mass Flow Rate: An instantaneous increase from –810 kg/s to approximately 2900 kg/s in 0.02 sec is observed (see Figure 4).

Break Pressure: The pressure in the break location is shown to decrease from 7.1 MPa to 1.8 MPa 0.02 sec after the break (see Figure 8). Shortly thereafter, the pressure increases to 5 MPa.

Vessel Pressure: The pressure in the vessel cell in which the break is located decreases from 7.1 MPa to 6.99 MPa shortly after the break (see Figure 31).

Break Velocity: The velocity of the break is shown to change from the initial value of –6 m/s to 22 m/s in 0.02 sec (See Figure 6).

Break Temperature: Changes from 465 K to 539.5 K in the first 0.02 sec (from subcooled to saturated conditions) (See Figure 10).

Break Void Fraction: The void fraction of the break mass flow rate changes from 0.0 to 0.5 in 0.1 sec (See Figure 12). At the end of the transient, the break mass flow rate is close to single-phase steam (See Figure 13).

Break Density: A decrease due to the phase change is observed. The density decreases from 880 kg/m^3 to 380 kg/m^3 in the first 0.05 sec after the initiation of the break (See Figure 14).

The key parameter data from this analysis in Figures 4 to 34 will be supplied to the INEEL for their component failure assessment.

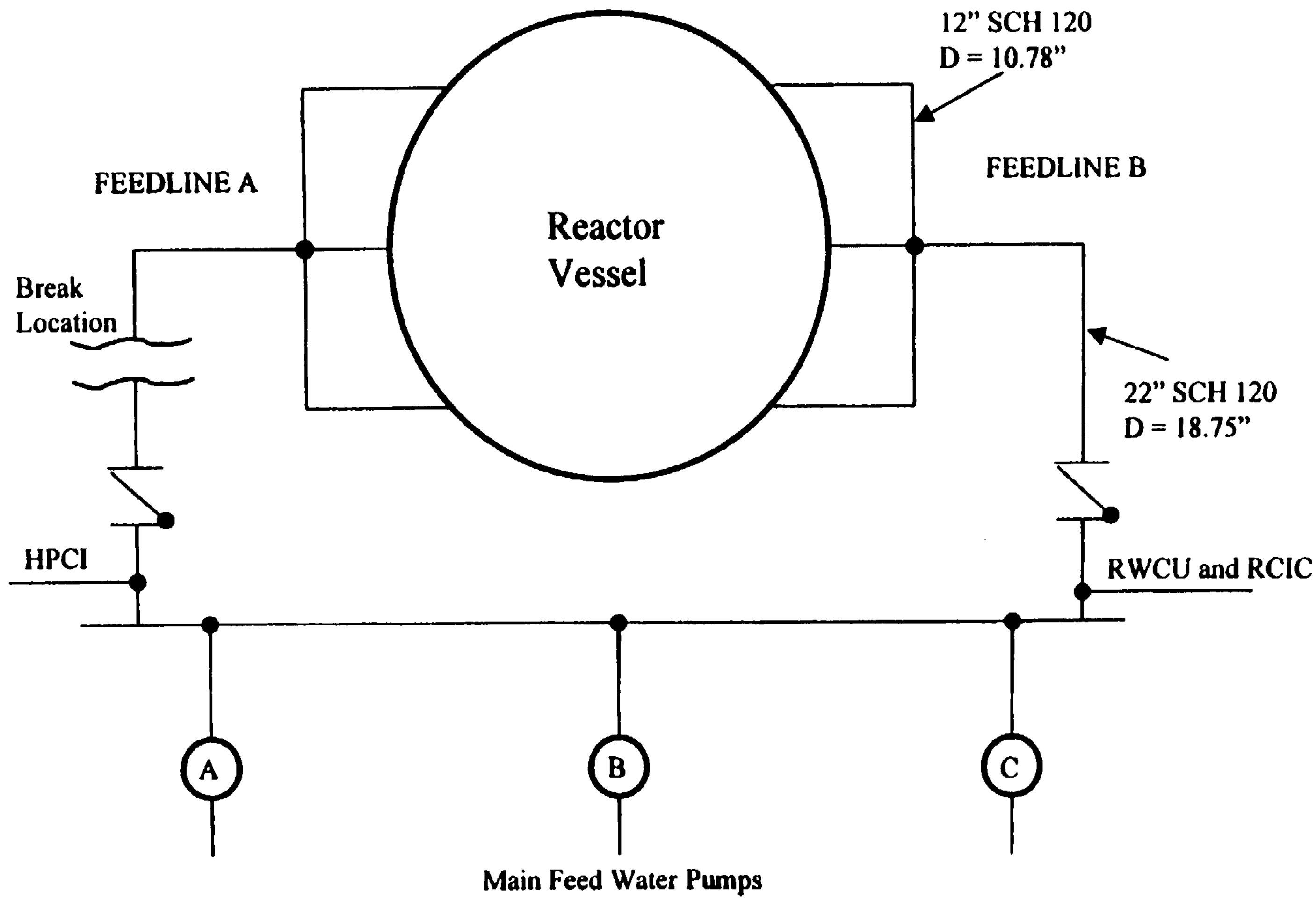


Figure 1: Feedwater Piping Diagram, Showing Break Location

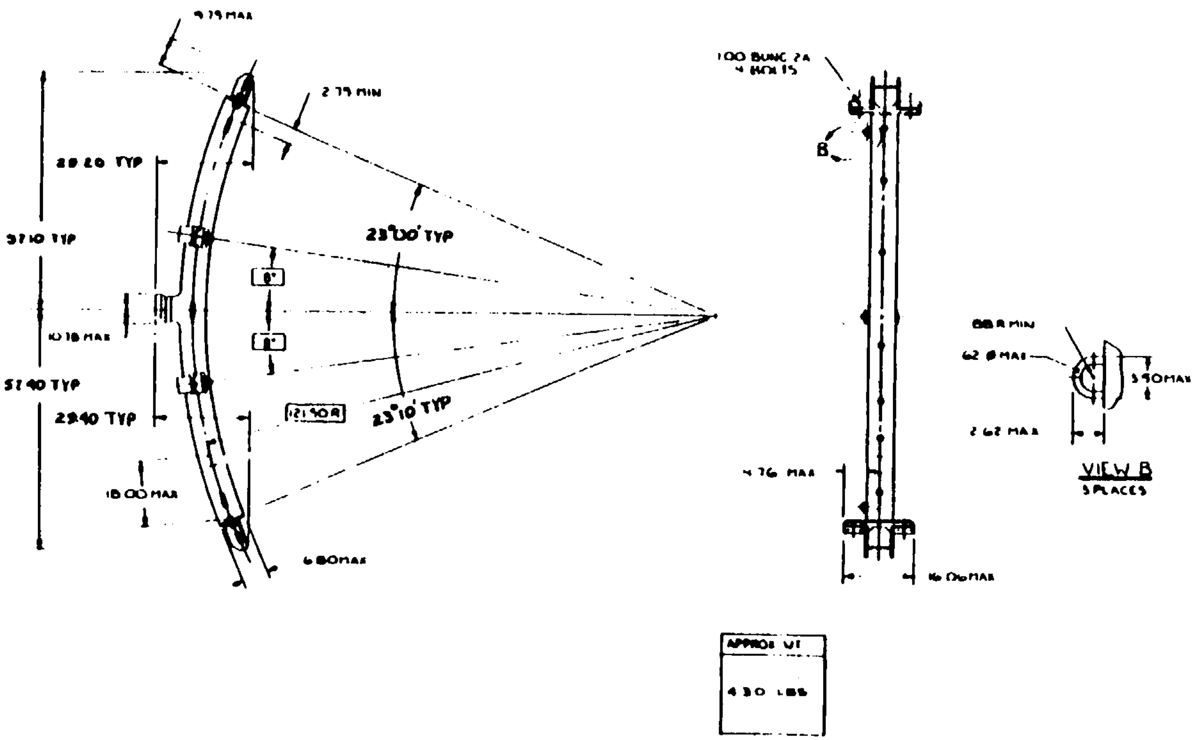


Figure 2: Feedwater Spargers

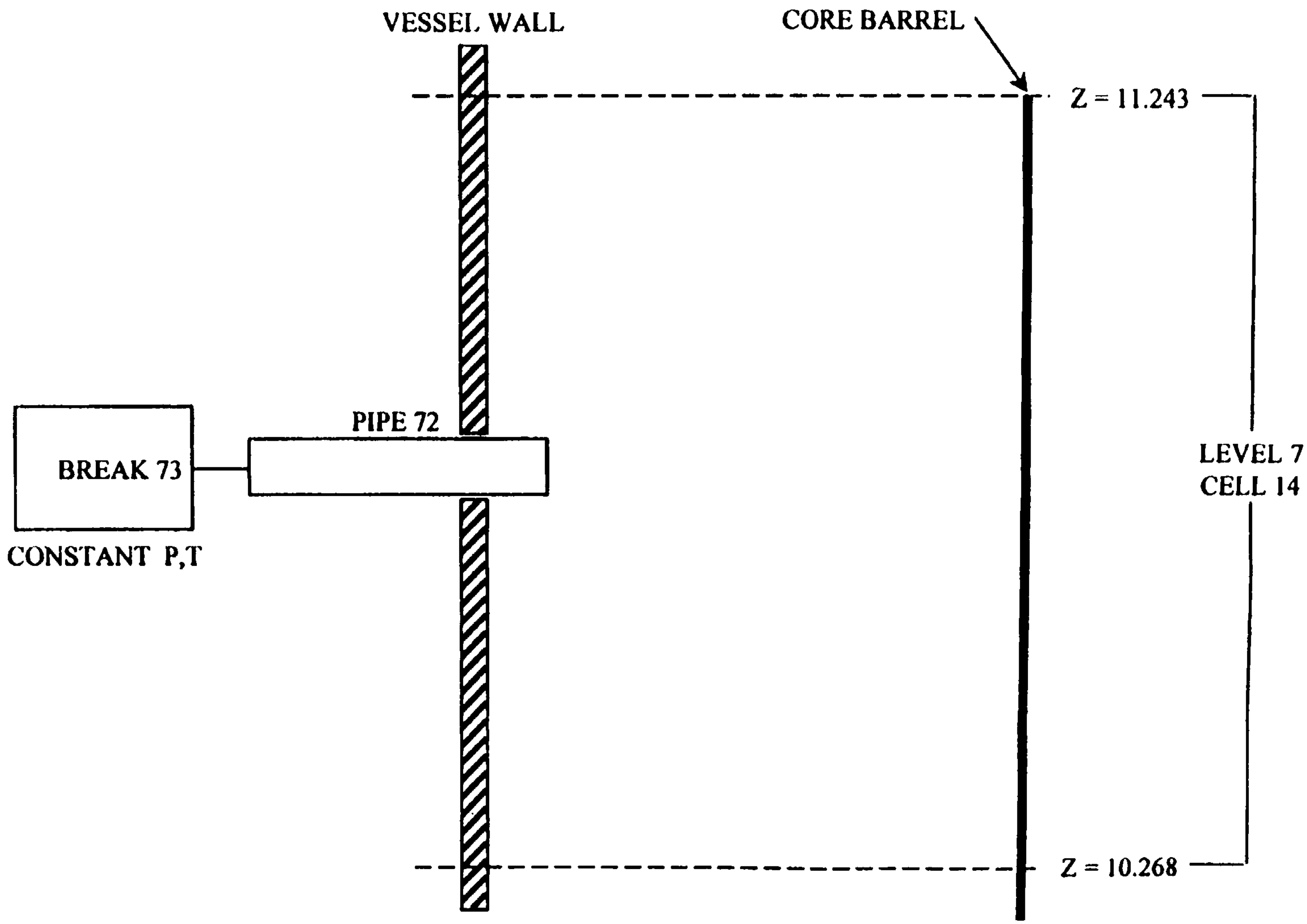


Figure 3: Break Nodalization

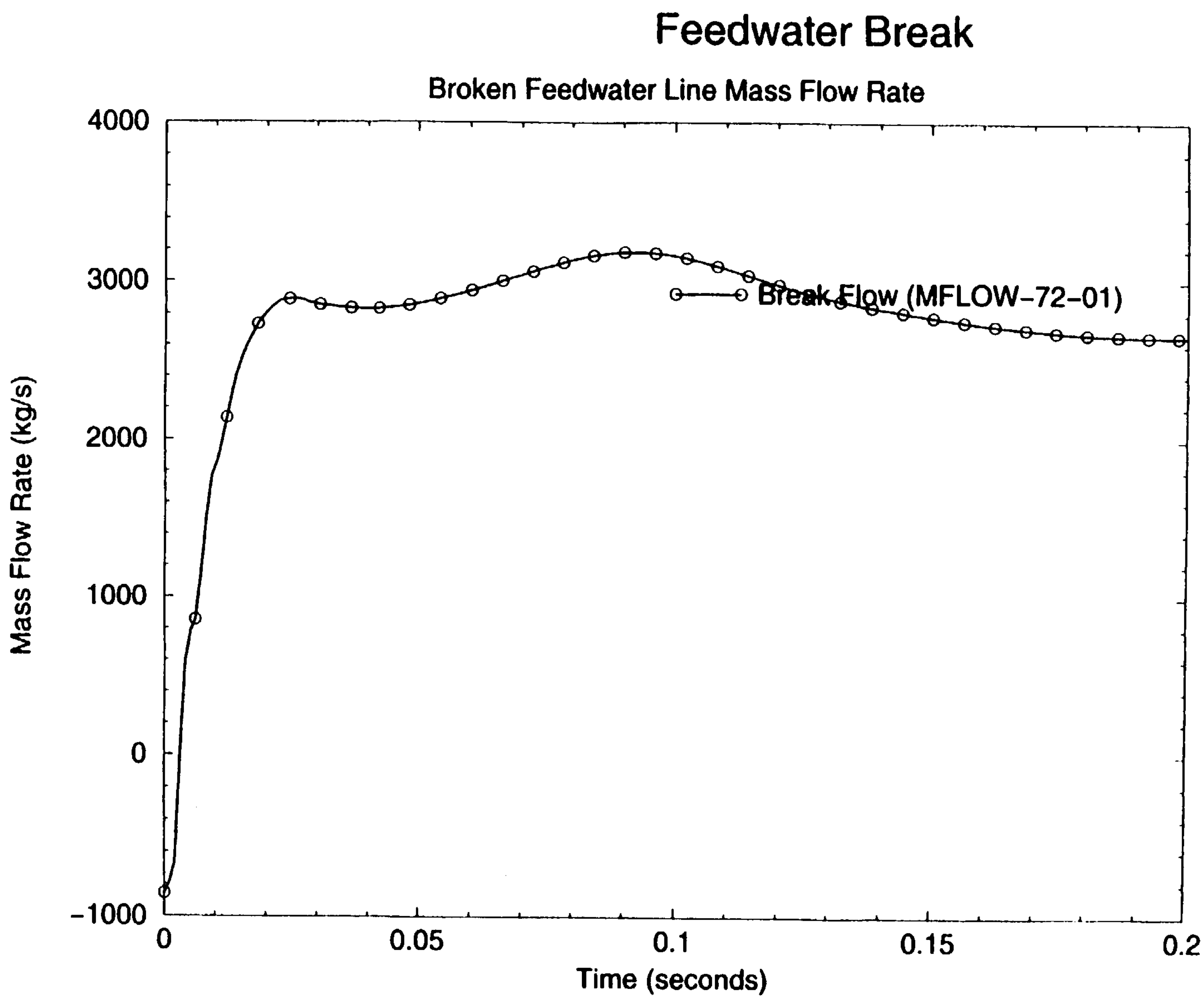


Figure 4: Mass Flow Rate in the Broken Feedwater Line (0-0.2 sec)

Feedwater Break

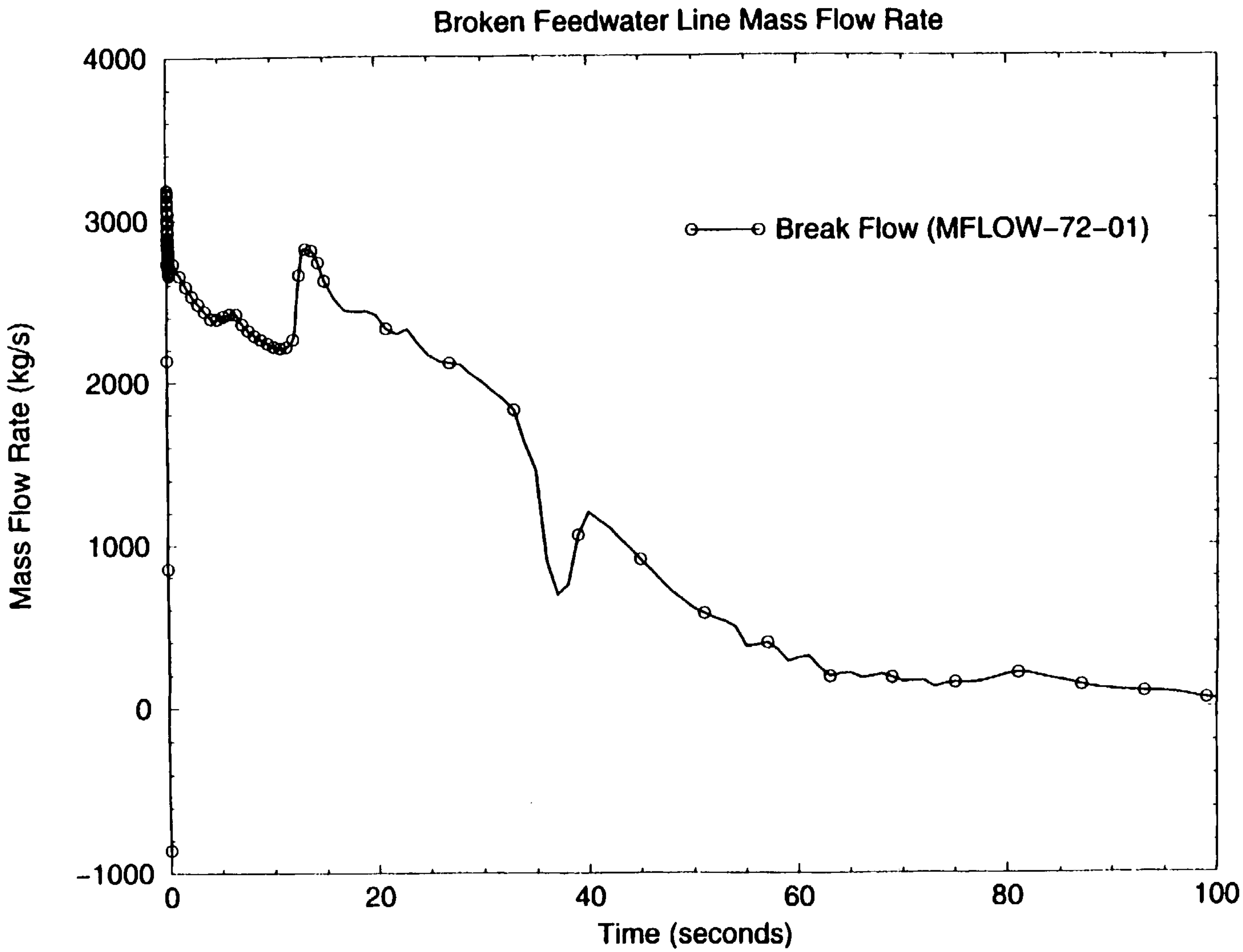


Figure 5: Mass Flow Rate in the Broken Feedwater Line (0-100 sec)

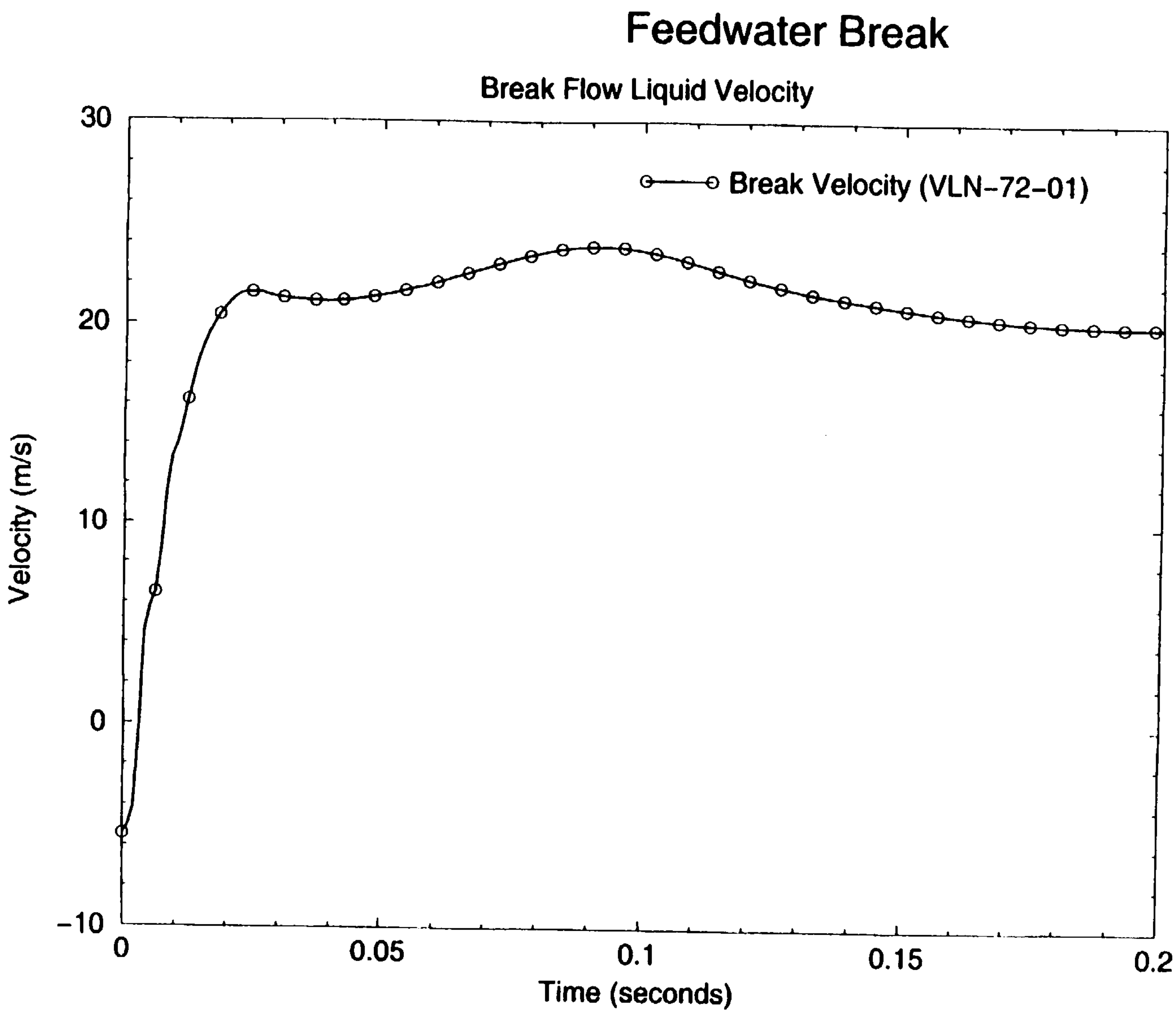


Figure 6: Liquid Velocity in the Broken Feedwater Line (0-0.2 sec)

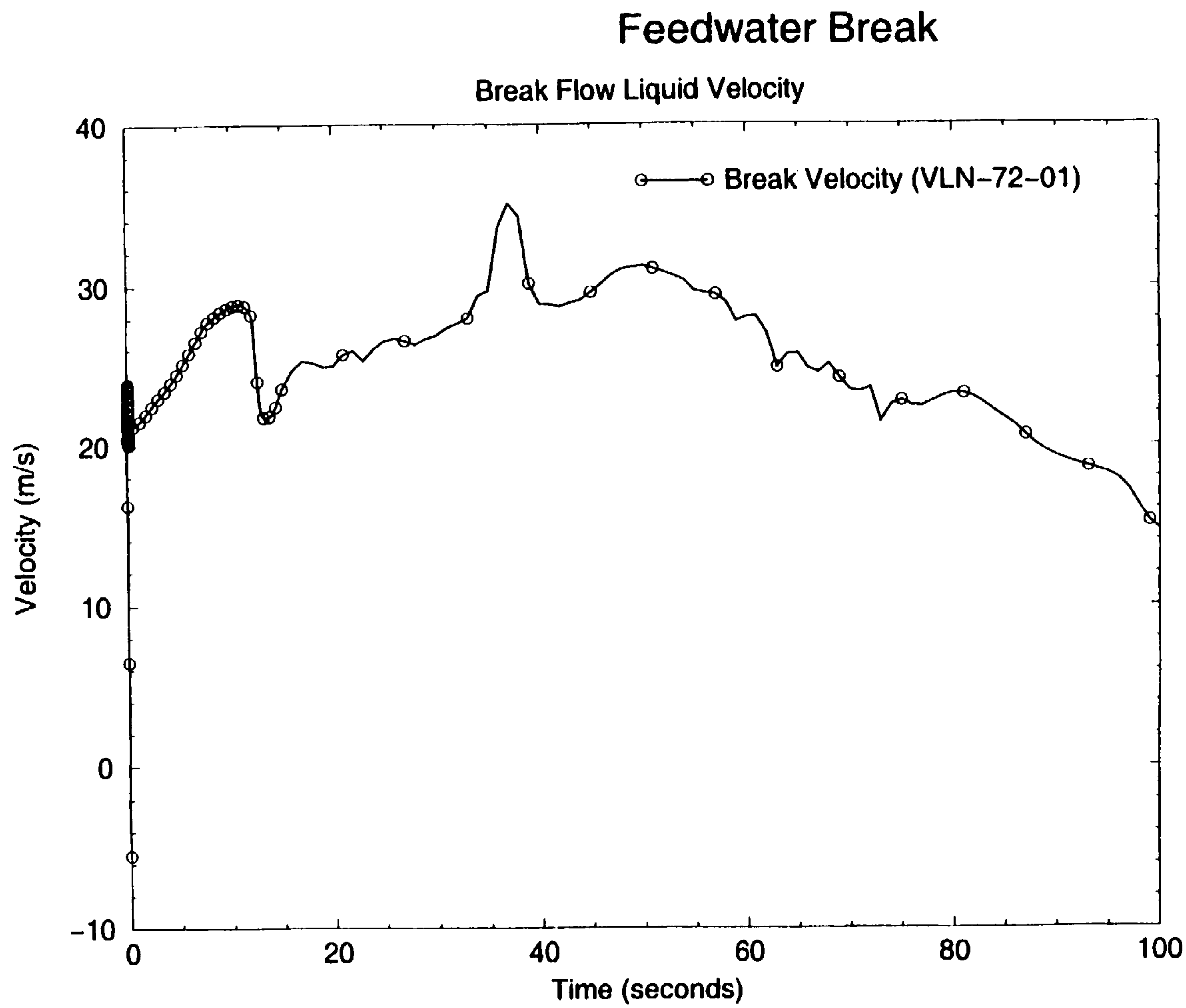


Figure 7: Liquid Velocity in the Broken Feedwater Line (0-100 sec)

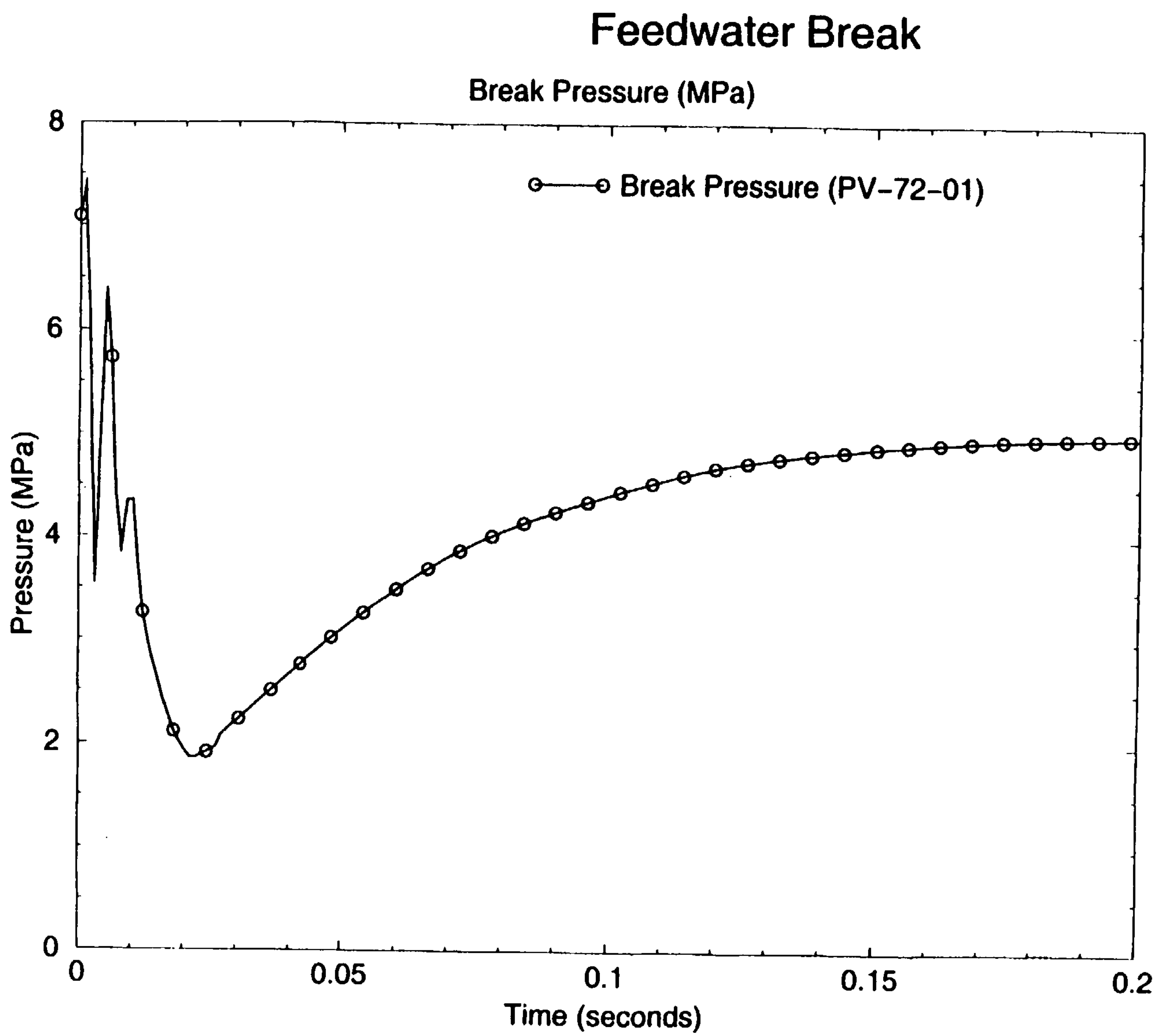


Figure 8: Upstream Break Pressure (0-0.2 sec)

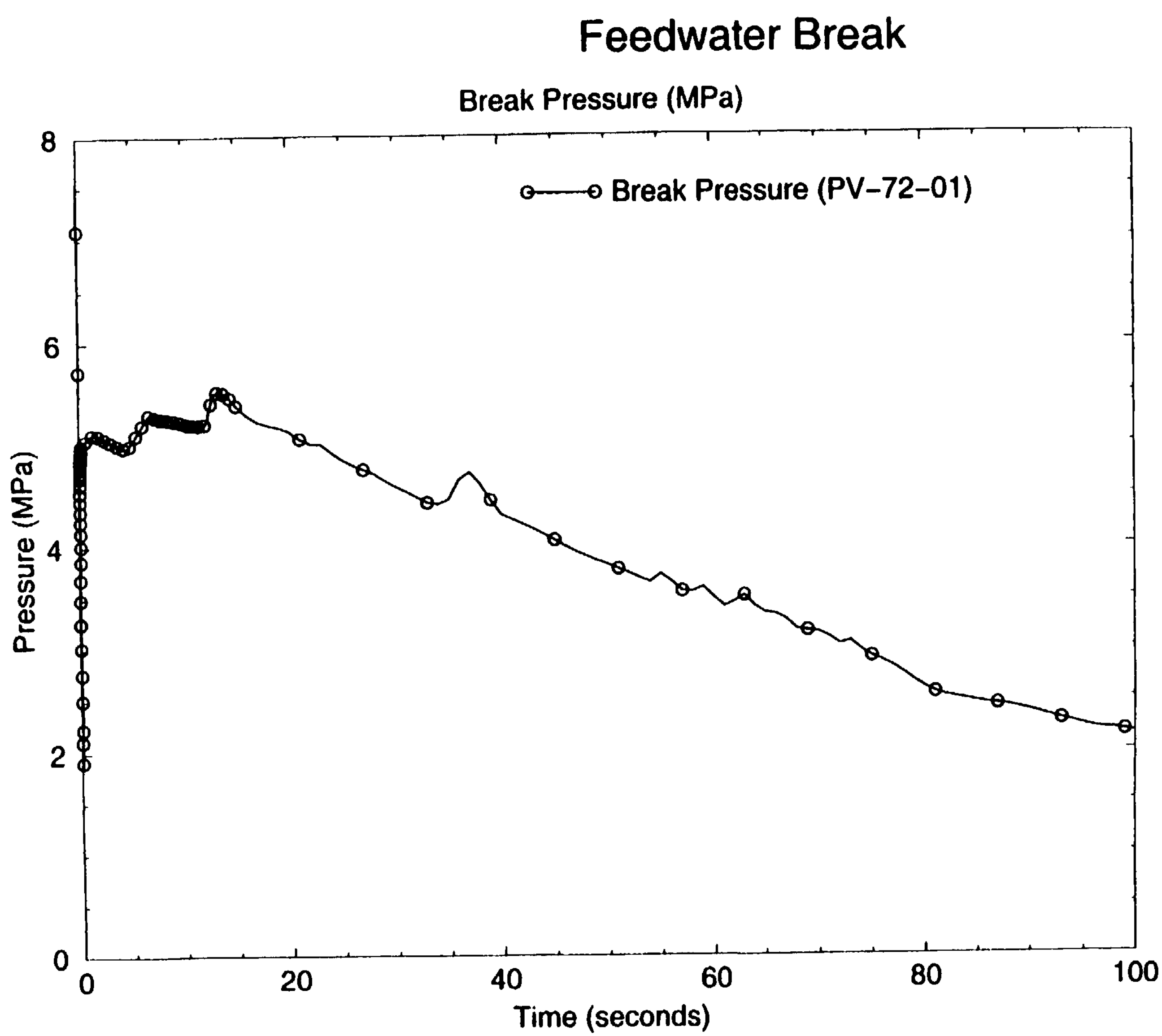


Figure 9: Upstream Break Pressure (0-100 sec)

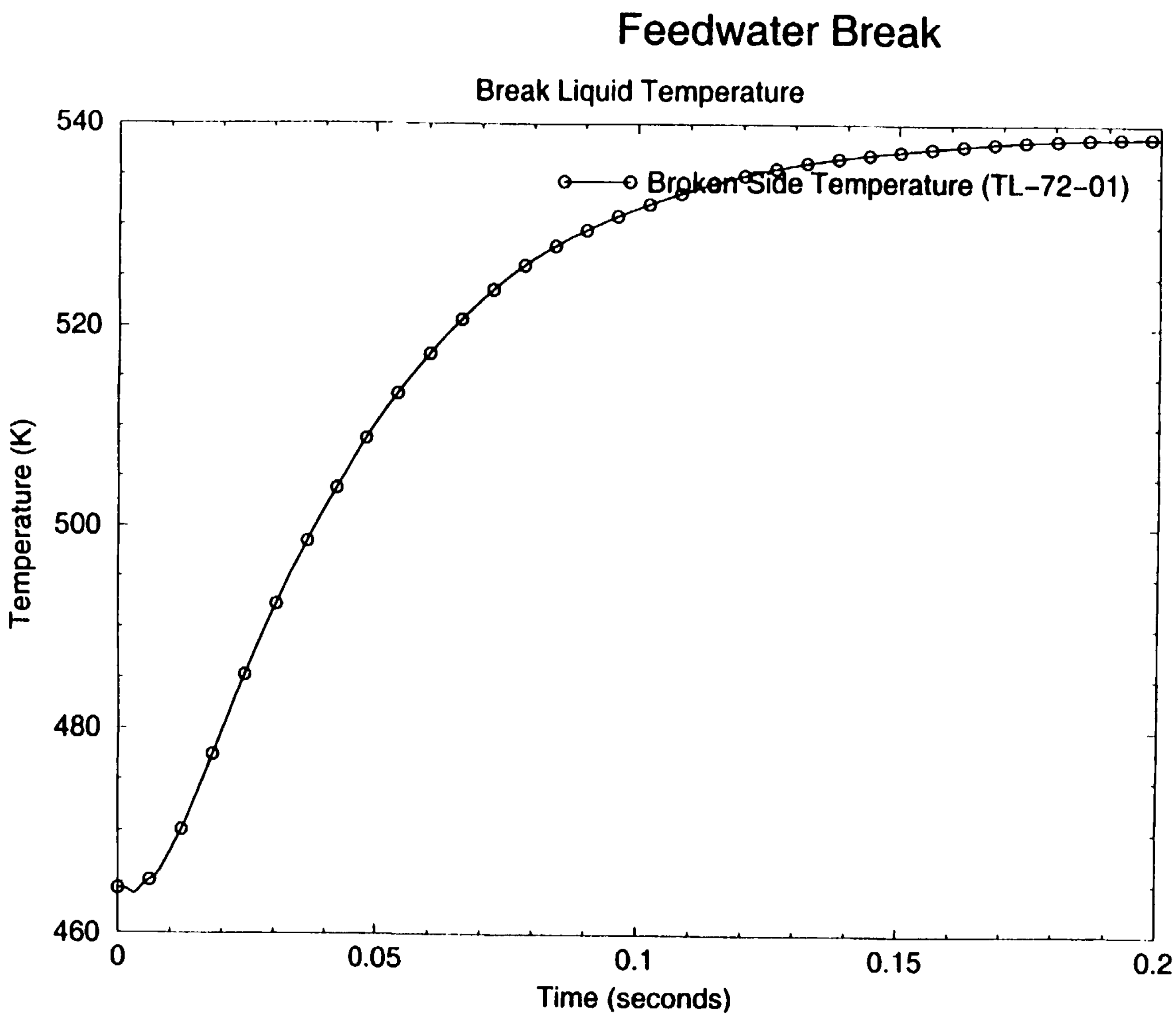


Figure 10: Upstream Break Temperature (0-0.2 sec)

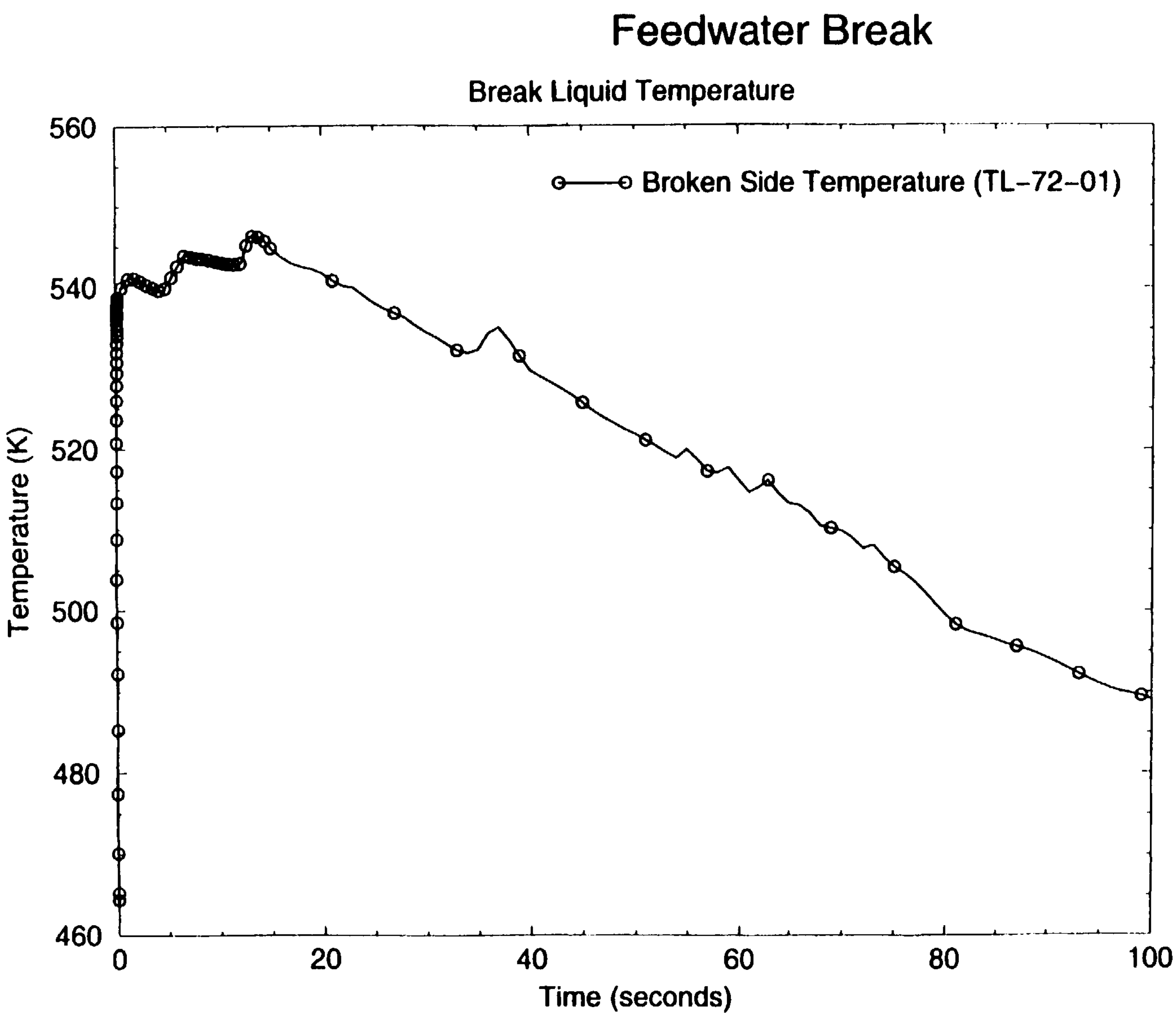


Figure 11: Upstream Break Temperature (0-100 sec)

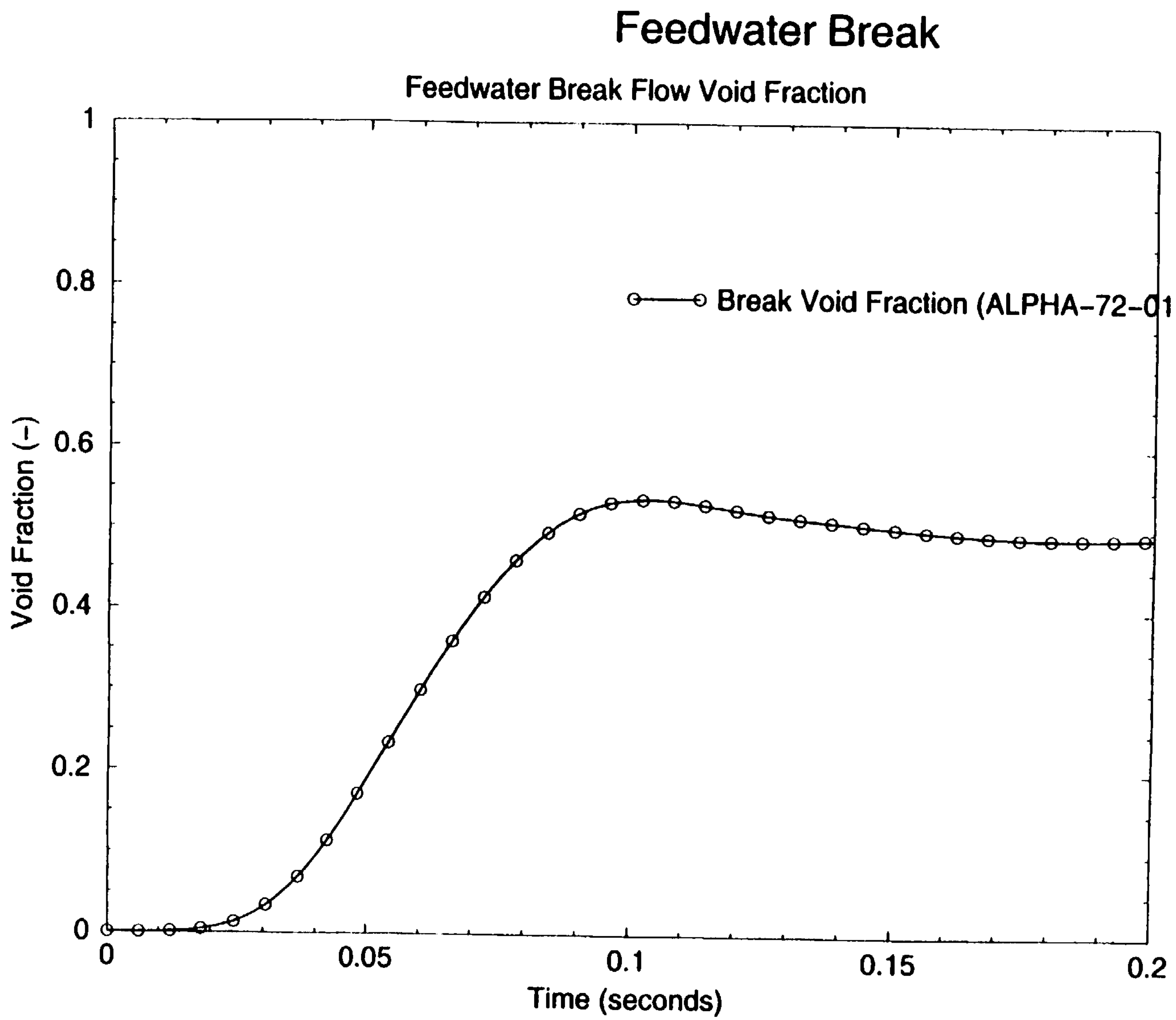


Figure 12: Upstream Break Void Fraction (0-0.2 sec)

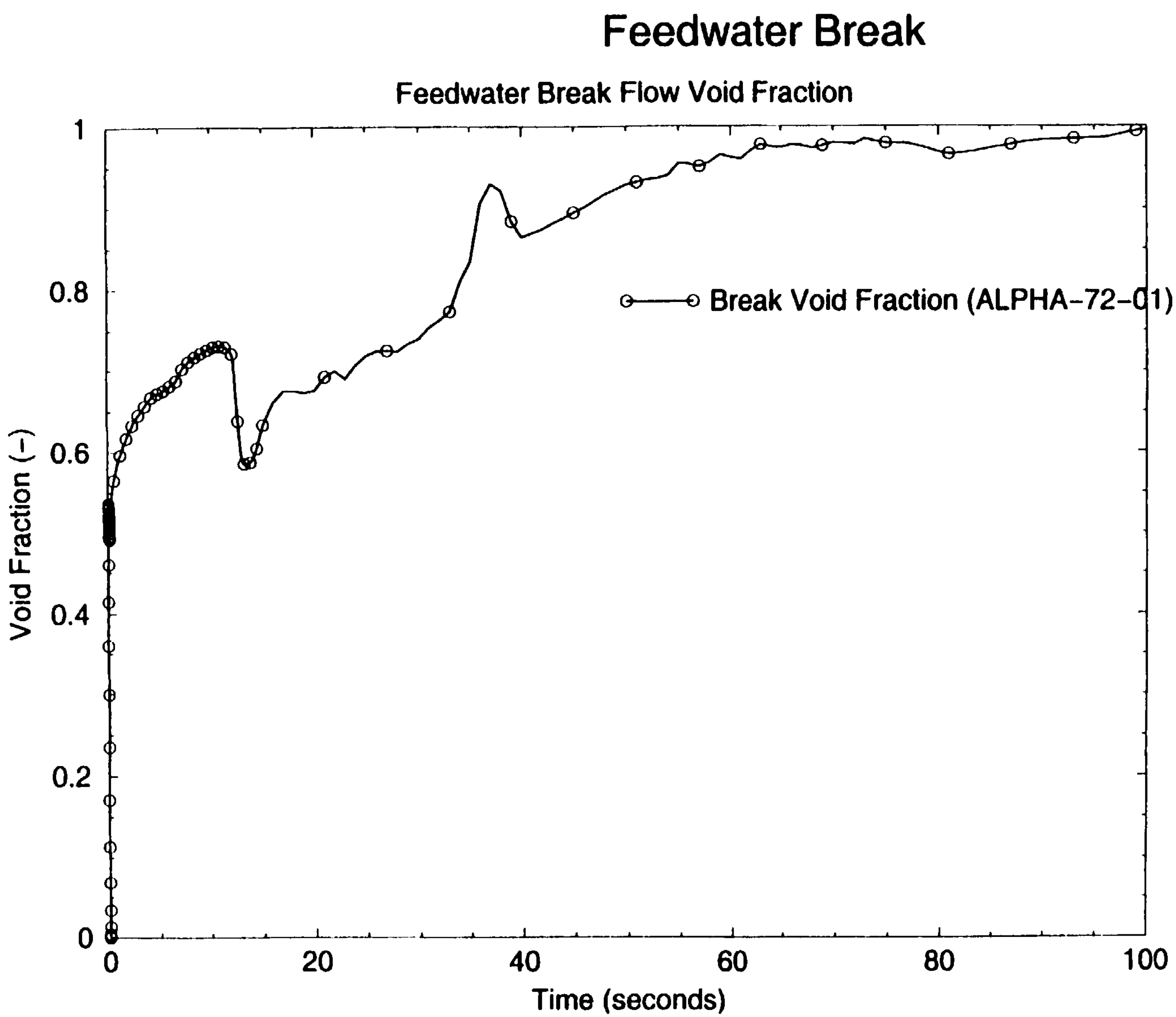


Figure 13: Upstream Break Void Fraction (0-100 sec)

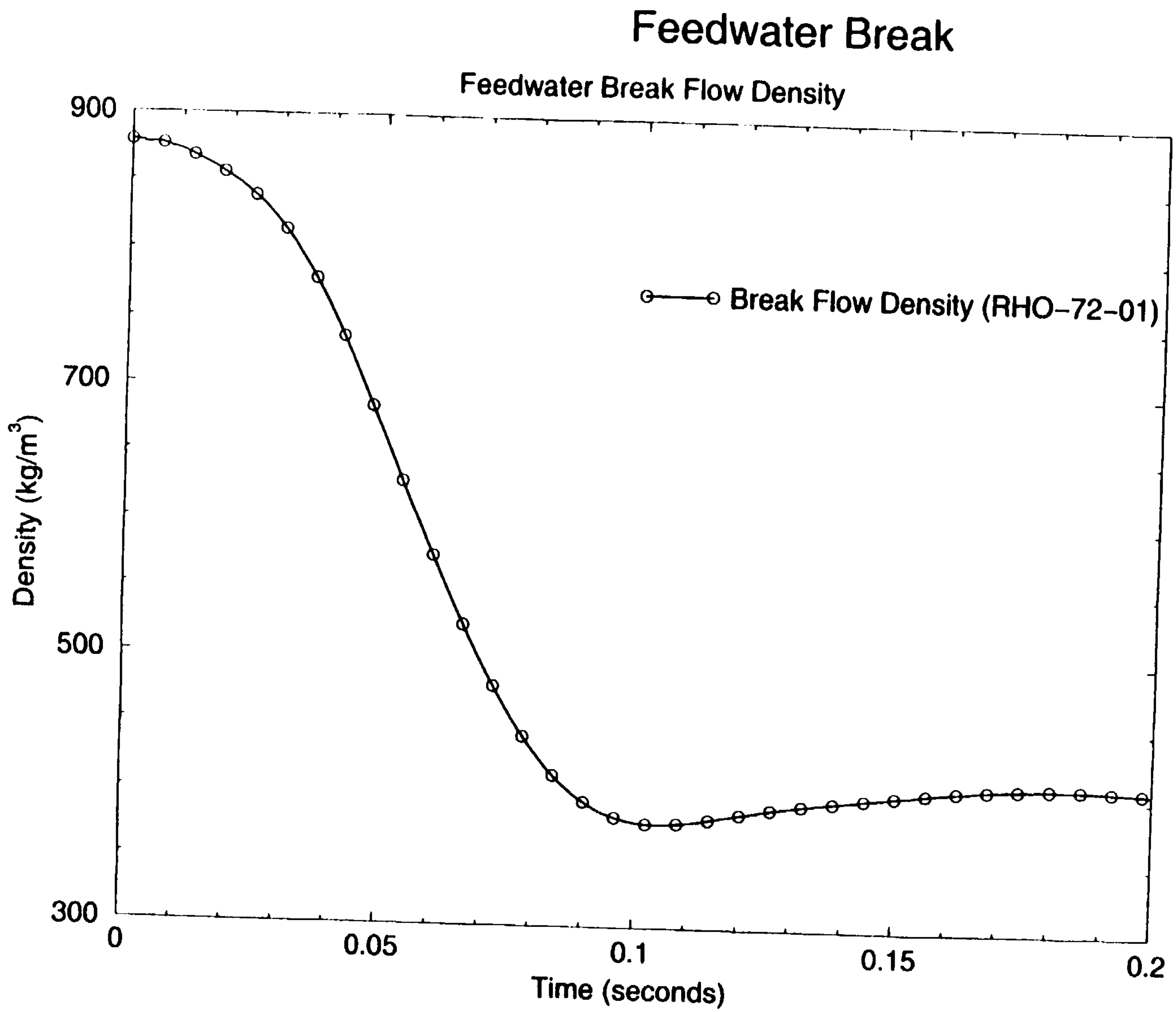


Figure 14: Upstream Break Density (0-0.2 sec)

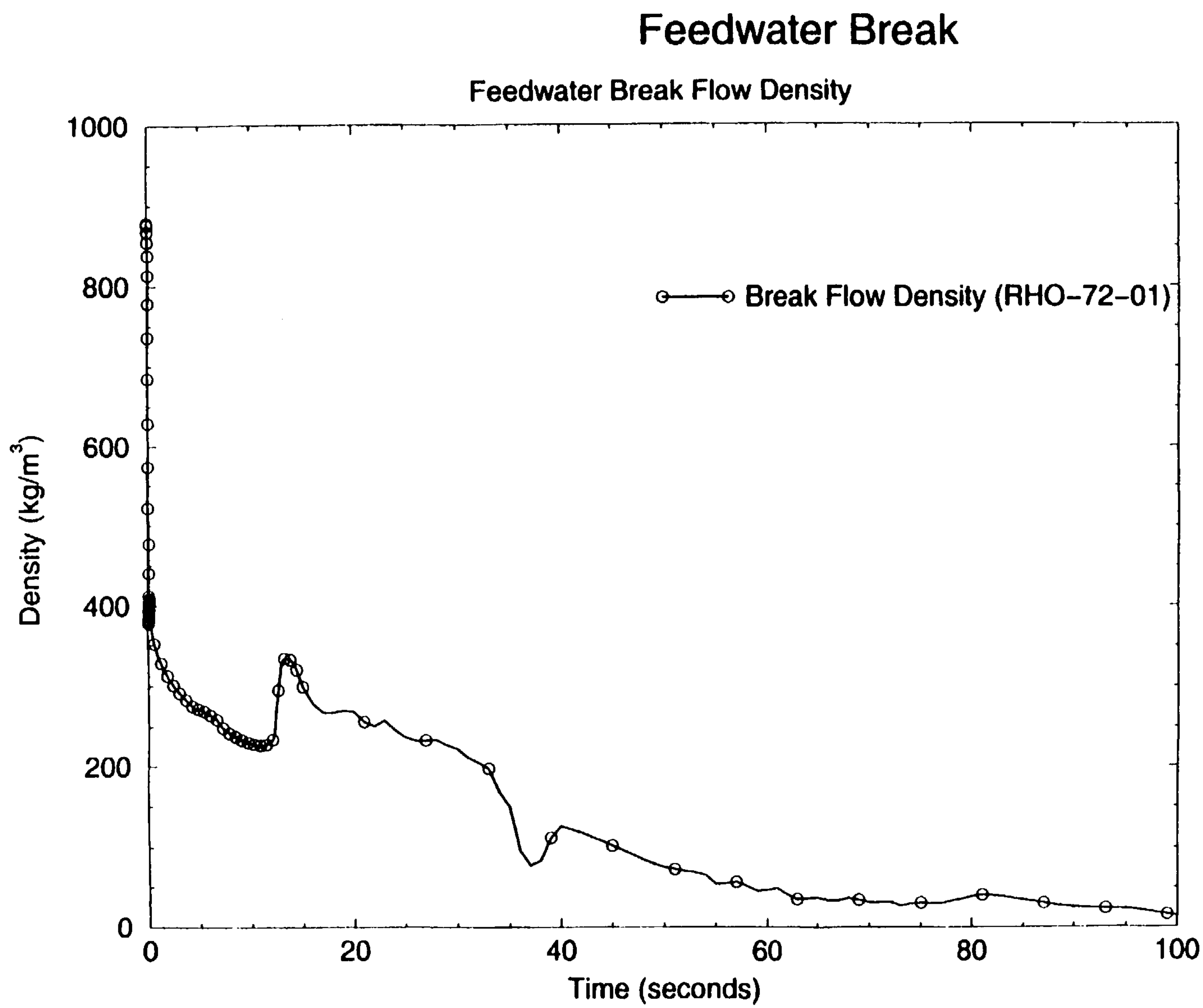


Figure 15: Upstream Break Density (0-100 sec)

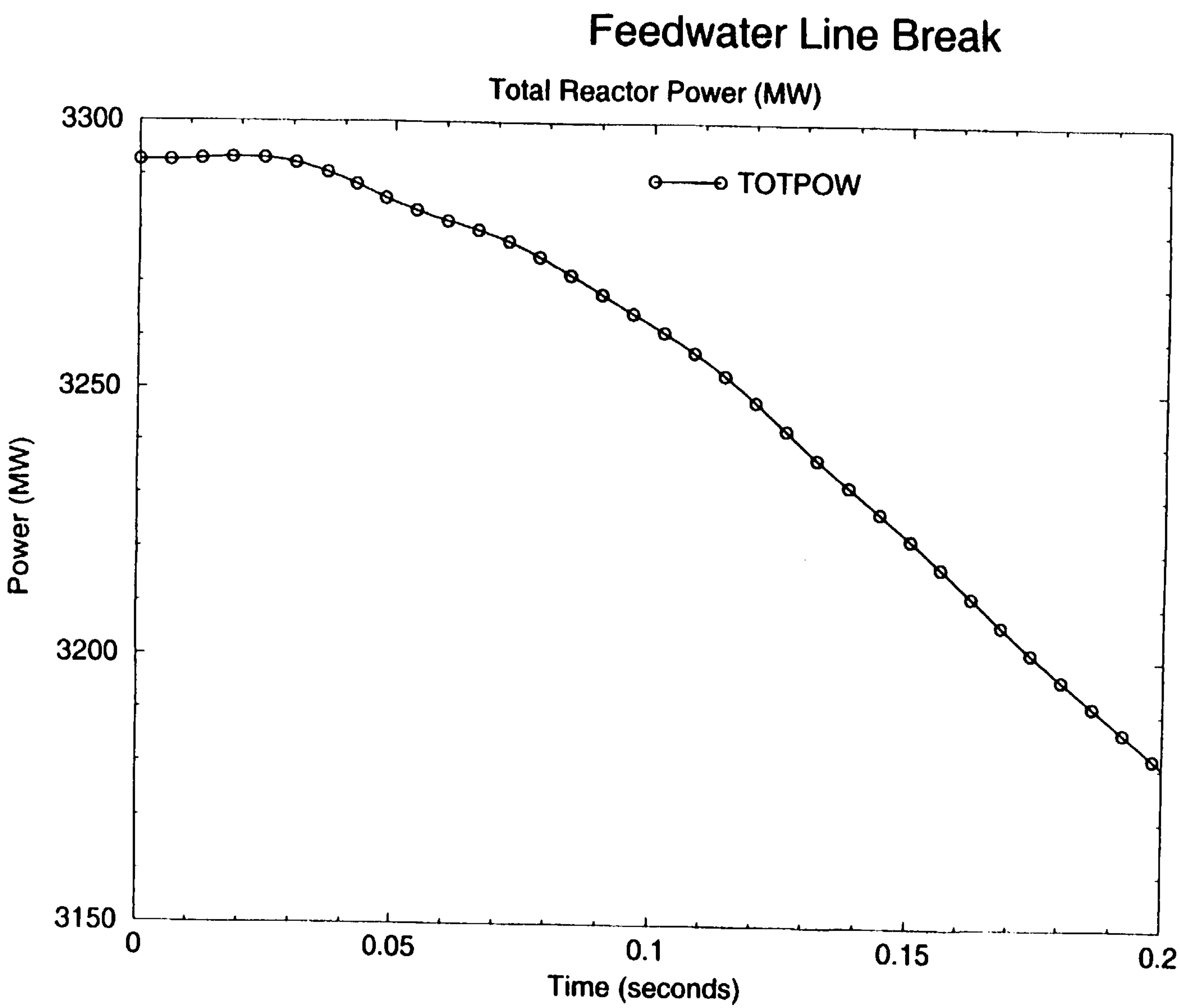


Figure 16: Total Reactor Power (0-0.2 sec)

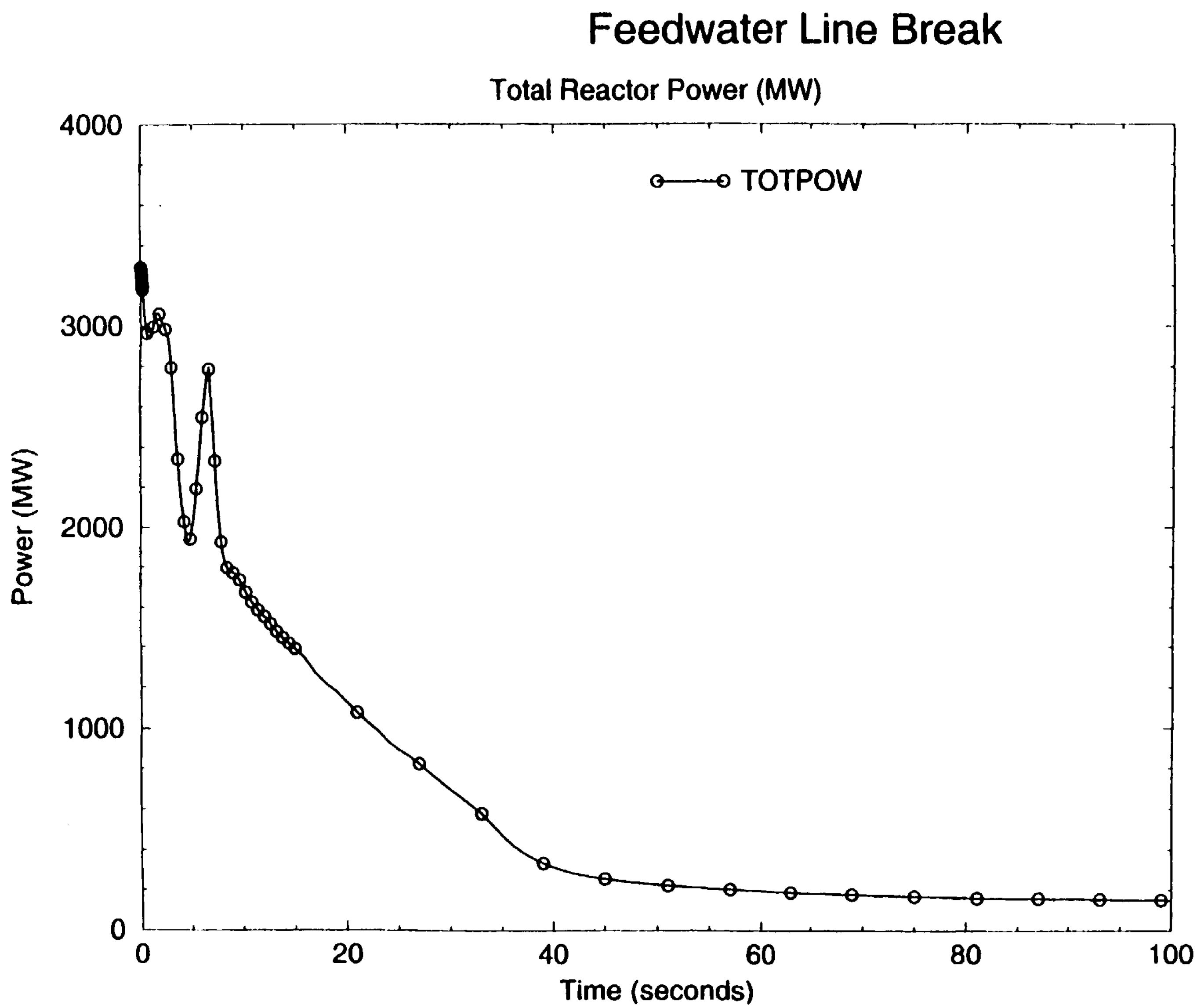


Figure 17: Total Reactor Power (0-100 sec)

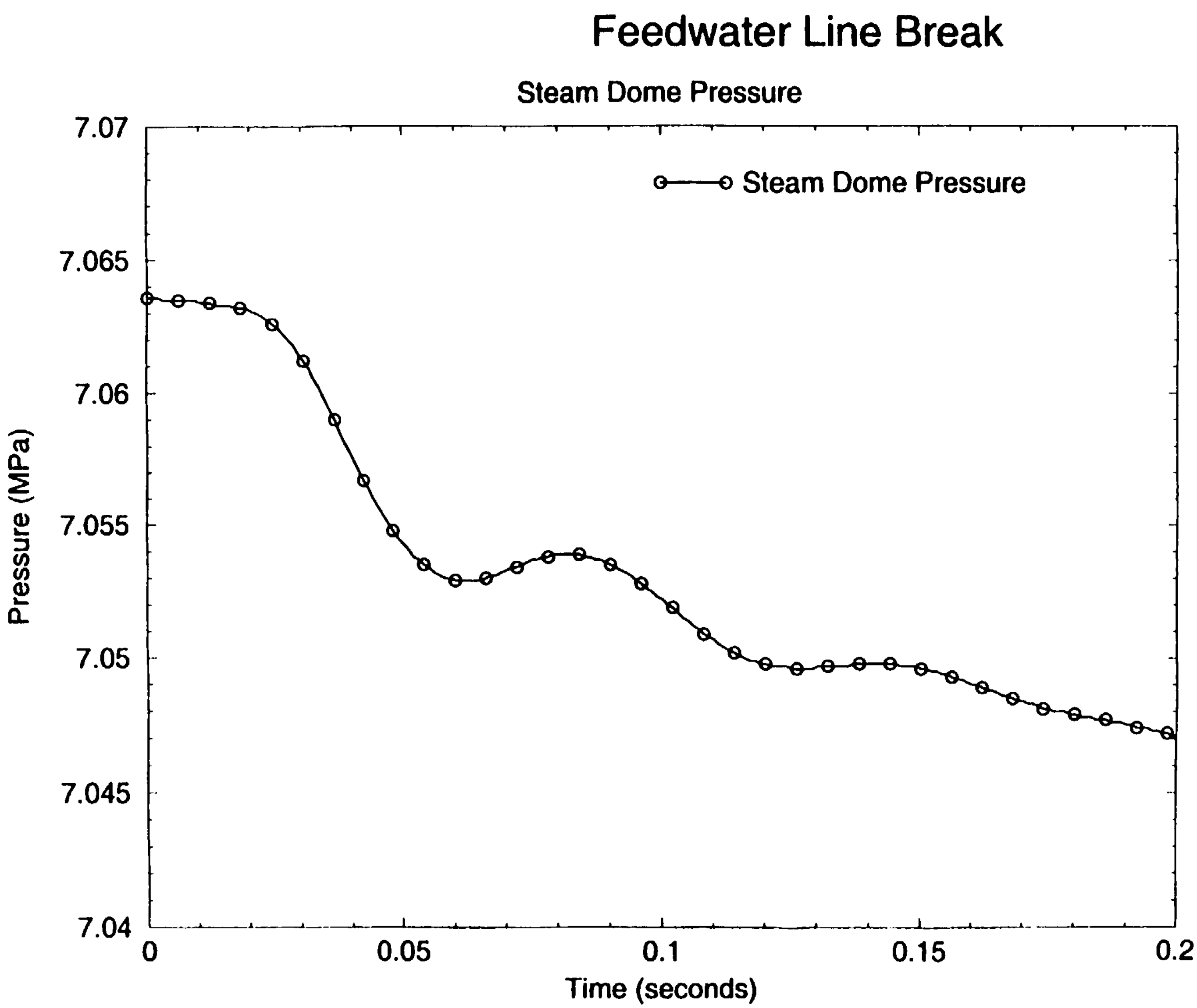


Figure 18: Steam Dome Pressure (0-0.2 sec)

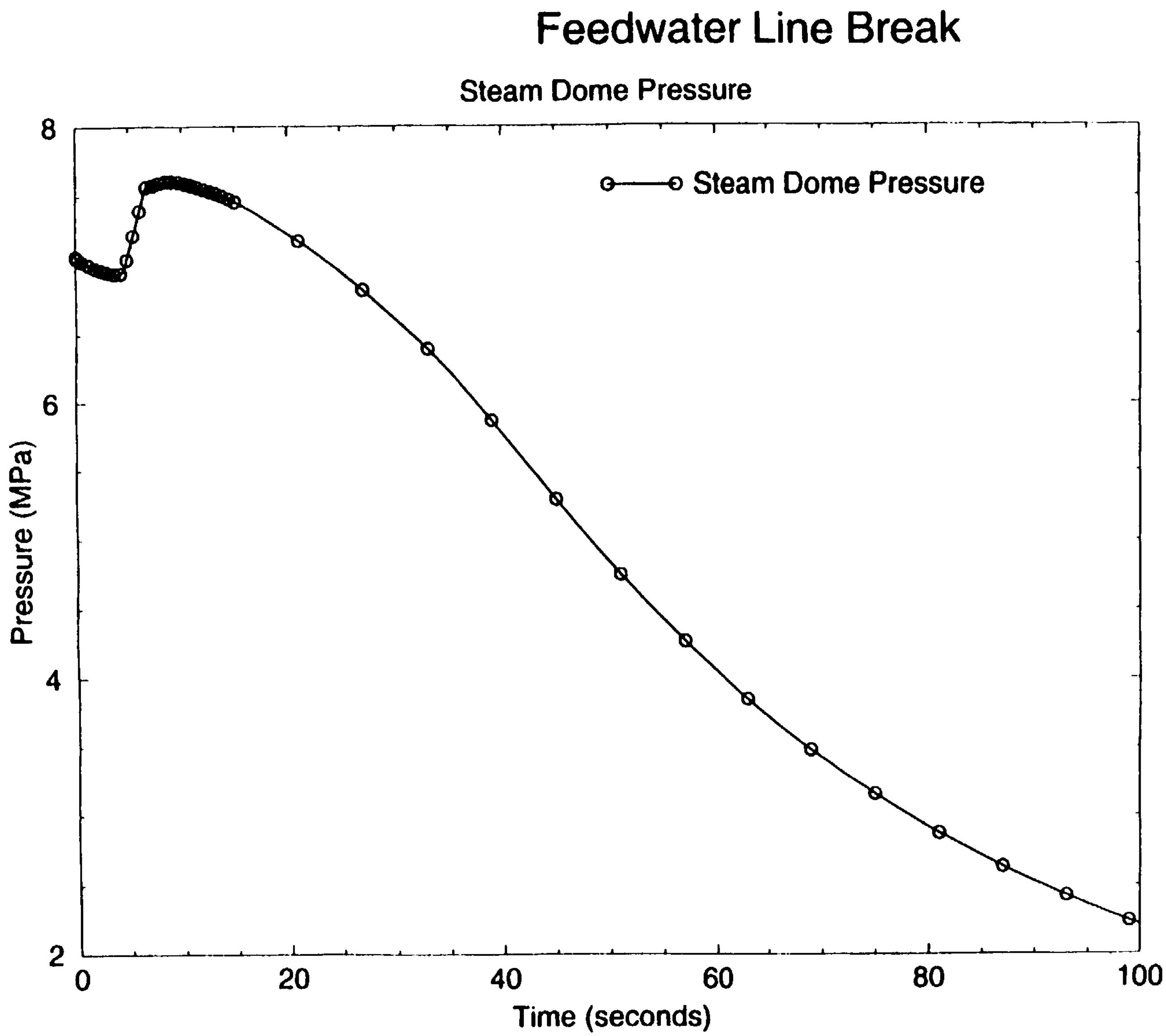


Figure 19: Steam Dome Pressure (0-100 sec)

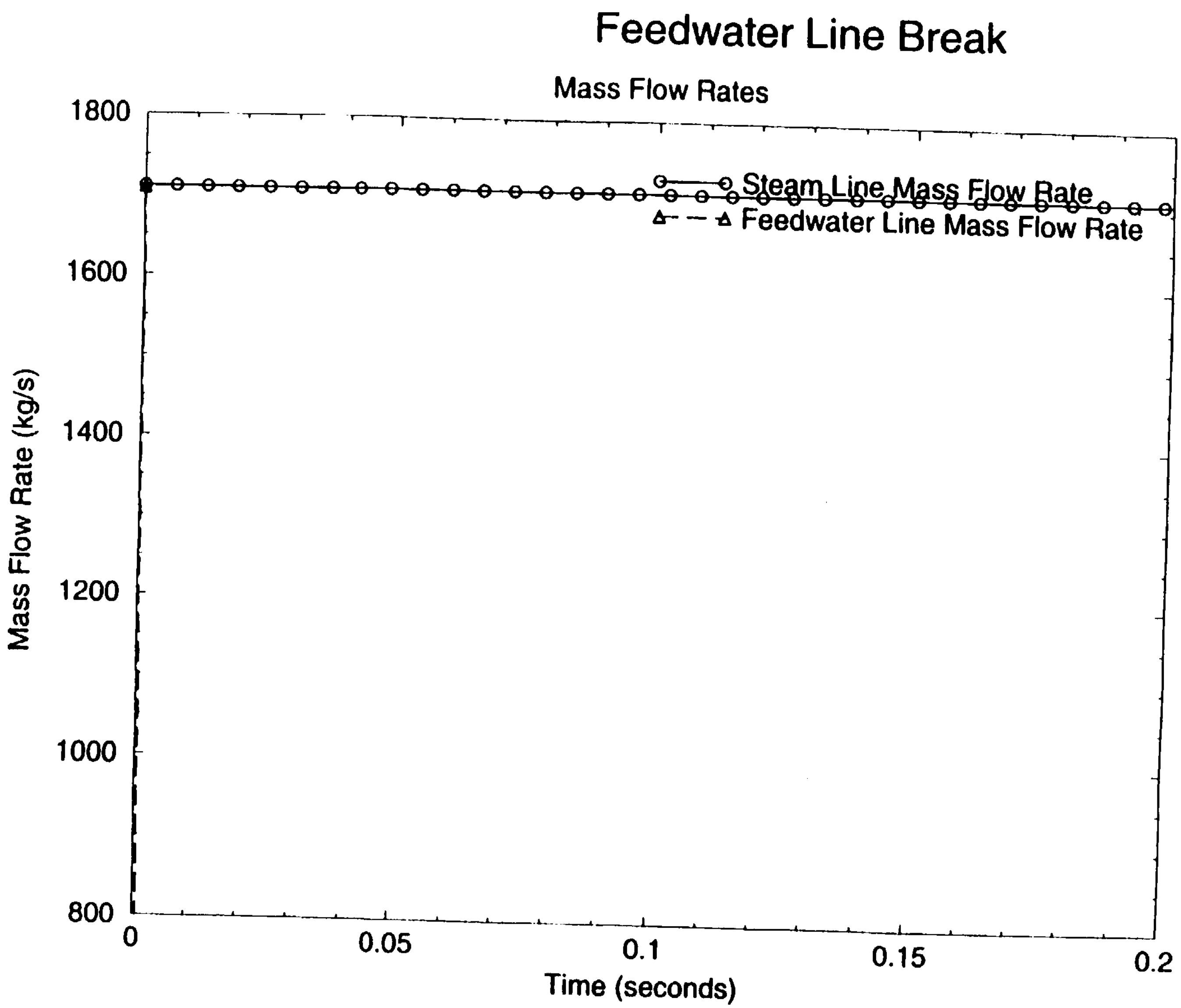


Figure 20: Steam Line and Feedwater Mass Flow Rates (0-0.2 sec)

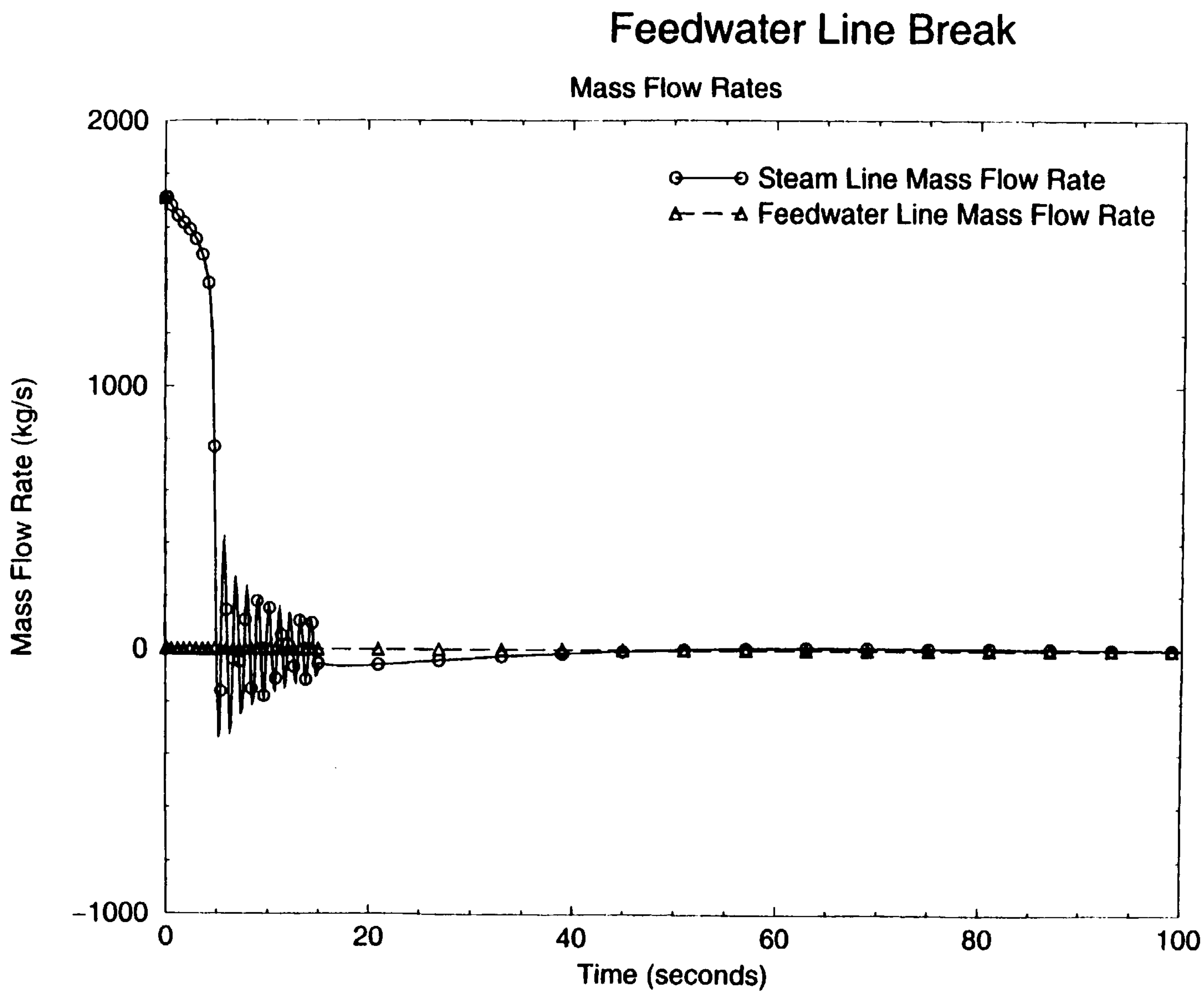


Figure 21: Steam Line and Feedwater Mass Flow Rates (0-100 sec)

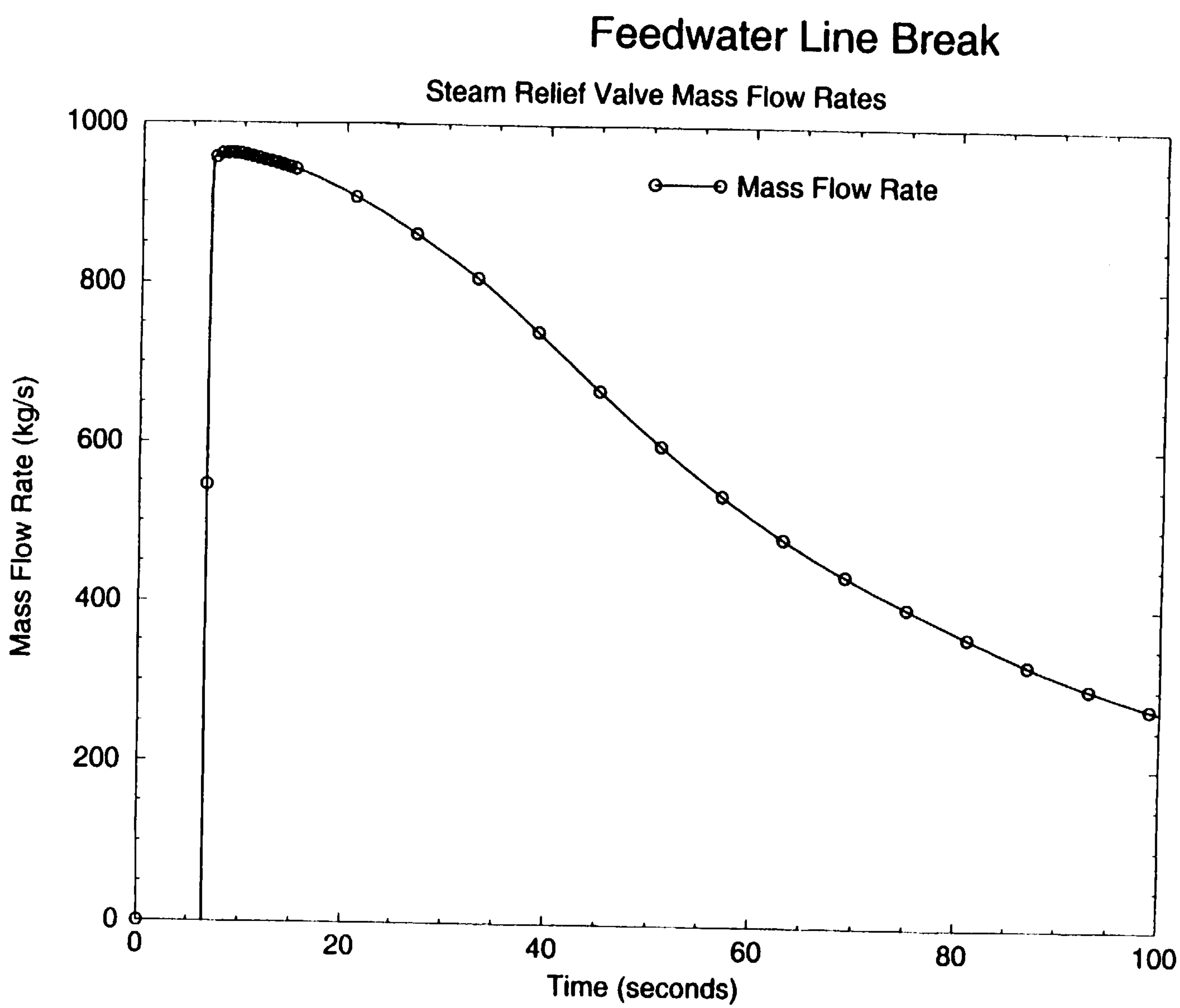


Figure 22: Steam Relief Valve Mass Flow Rate (0-100 sec)

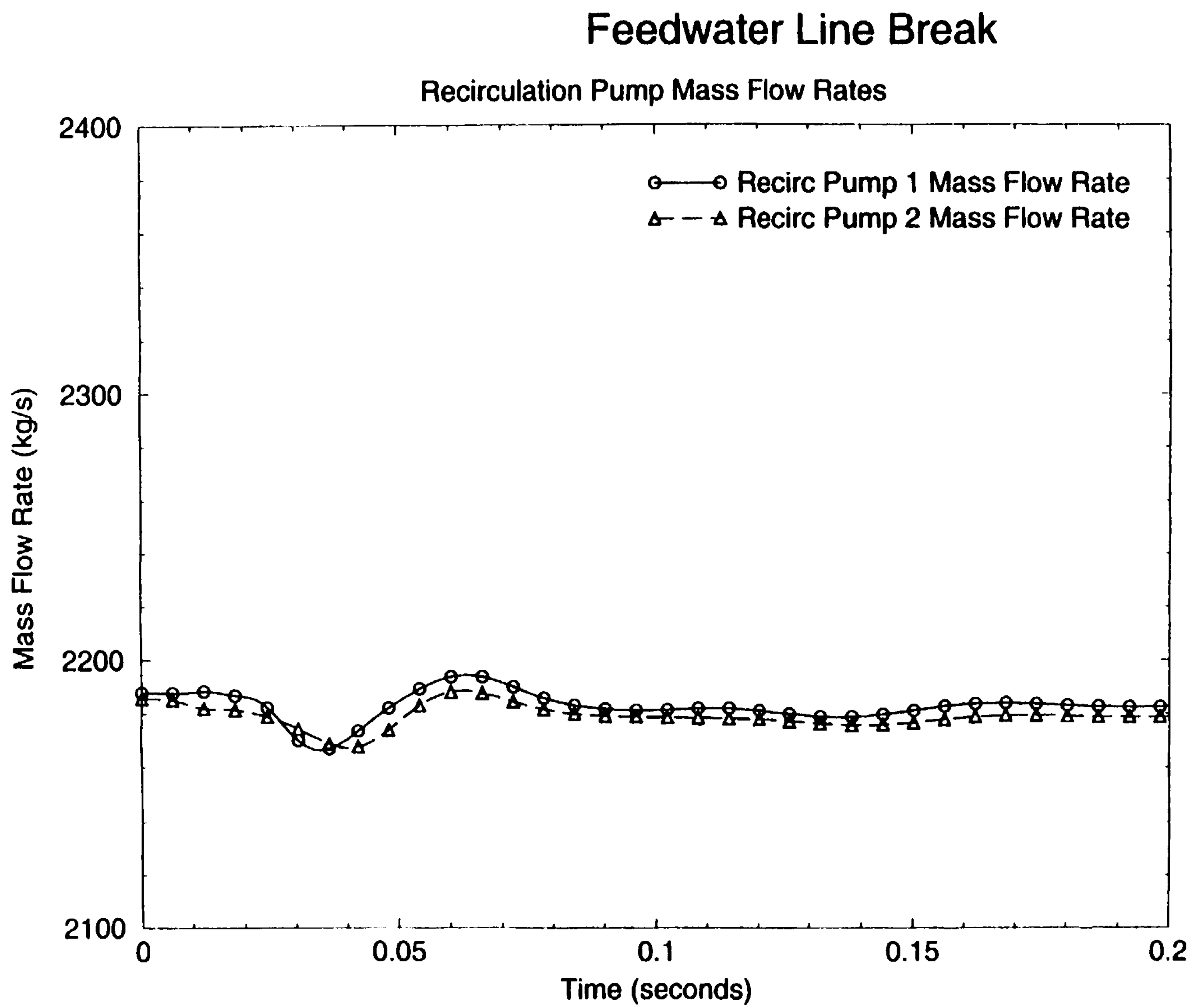


Figure 23: Recirculation Pump 1 and 2 Mass Flow Rates (0-0.2 sec)

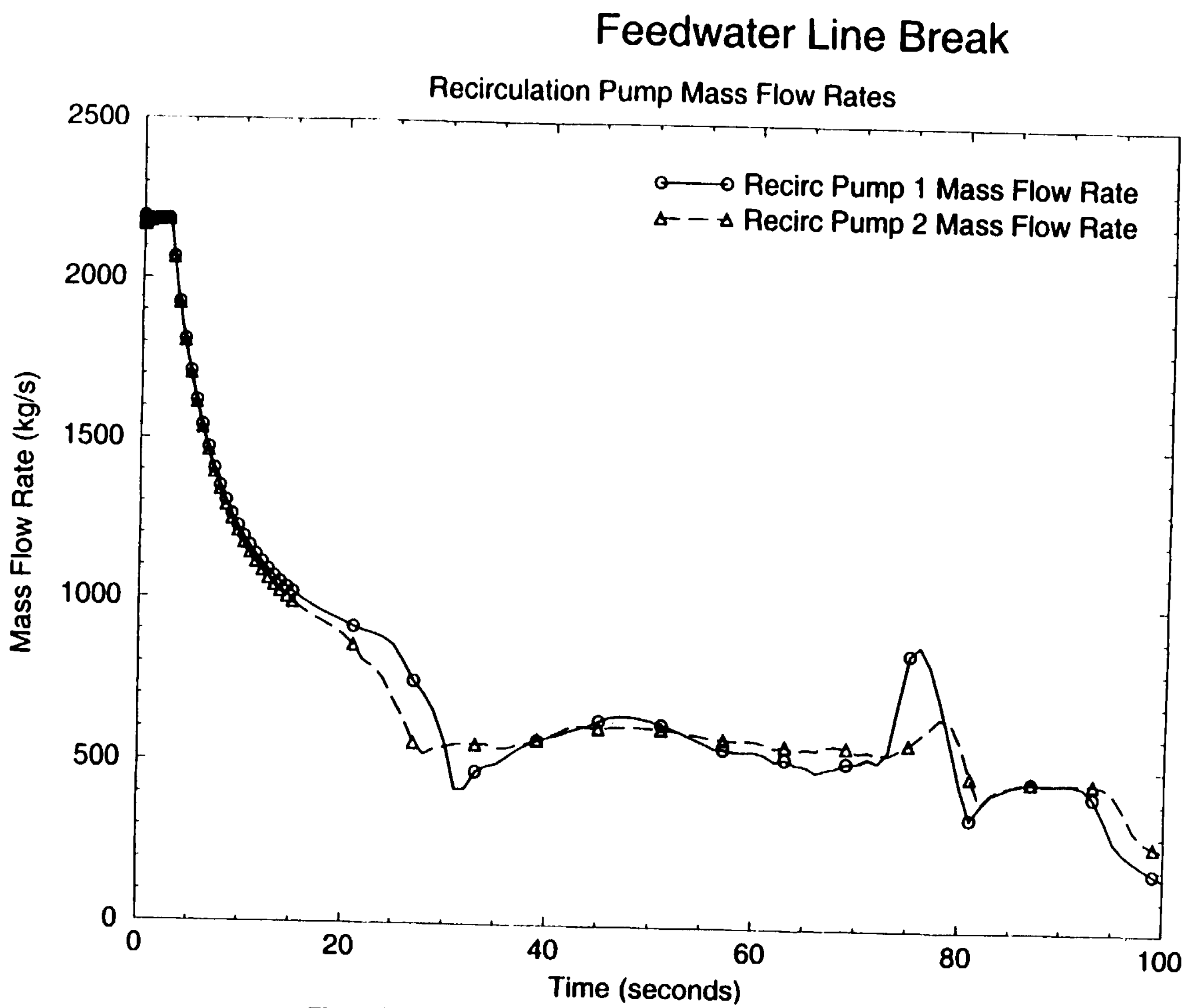


Figure 24: Recirculation Pump 1 and 2 Mass Flow Rates (0-100 sec)

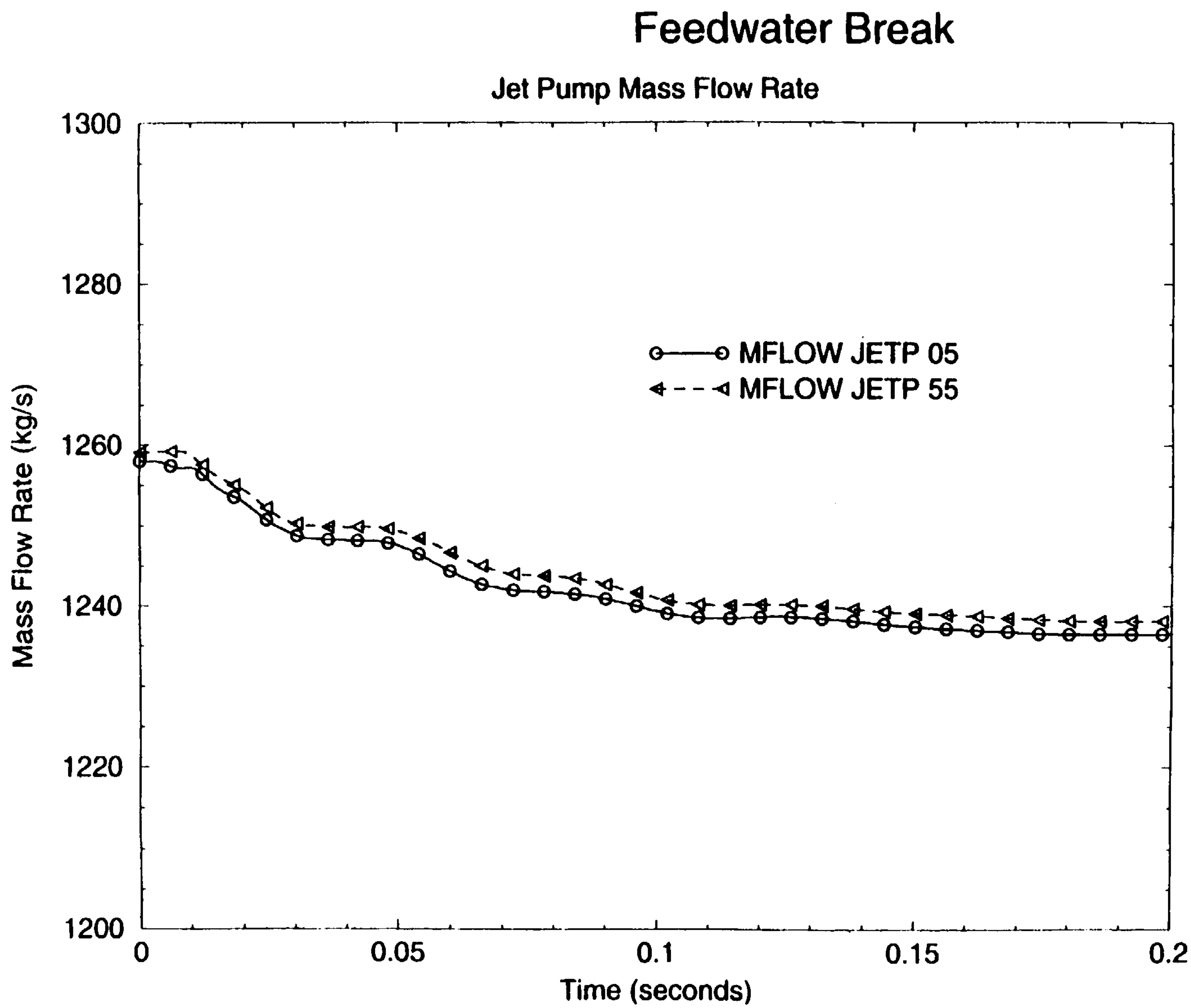


Figure 25: Mass Flow Rate in Jet Pump Components 5 and 55 (0-0.2 sec)

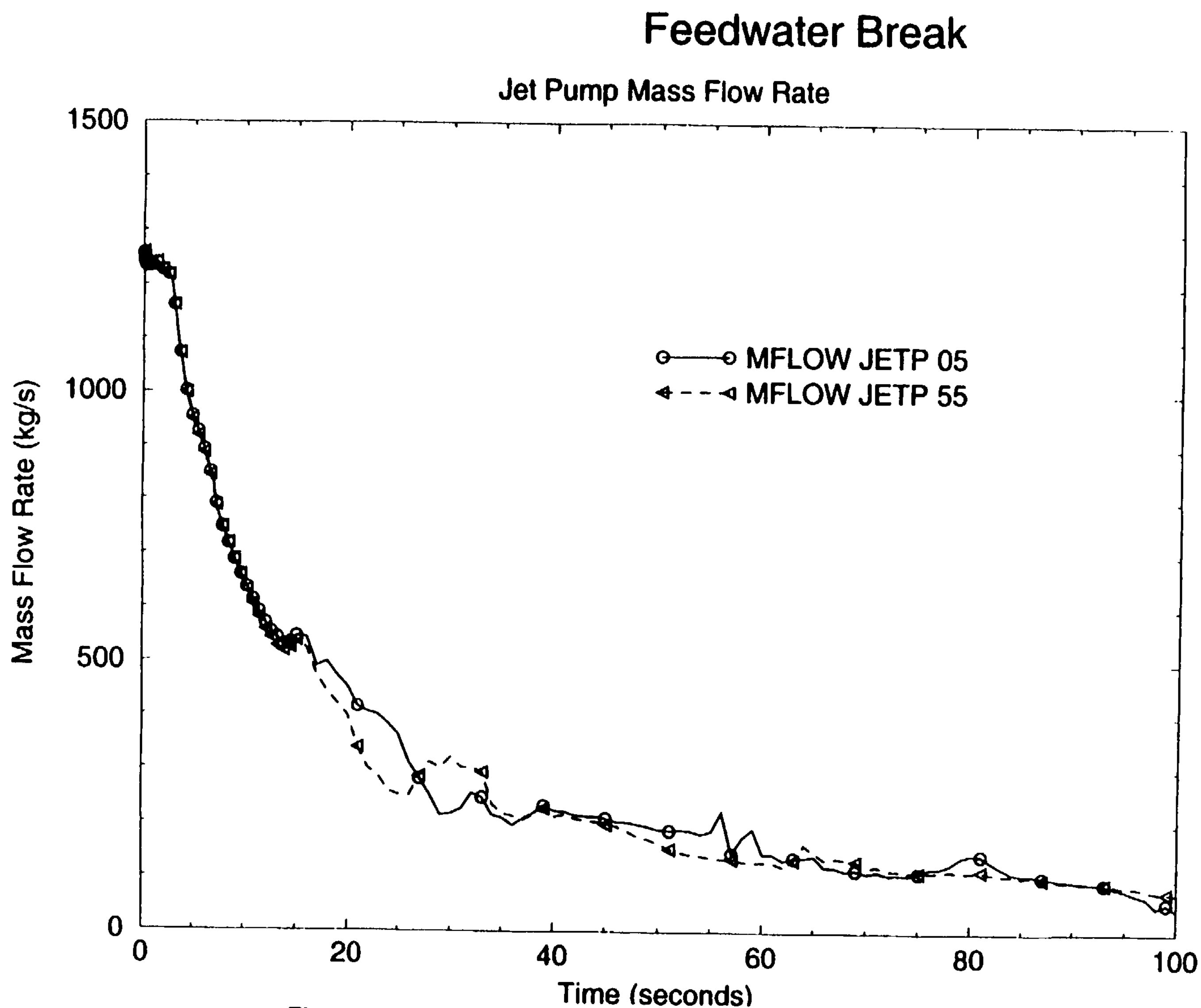


Figure 26: Mass Flow Rate in Jet Pump Components 5 and 55 (0-100 sec)

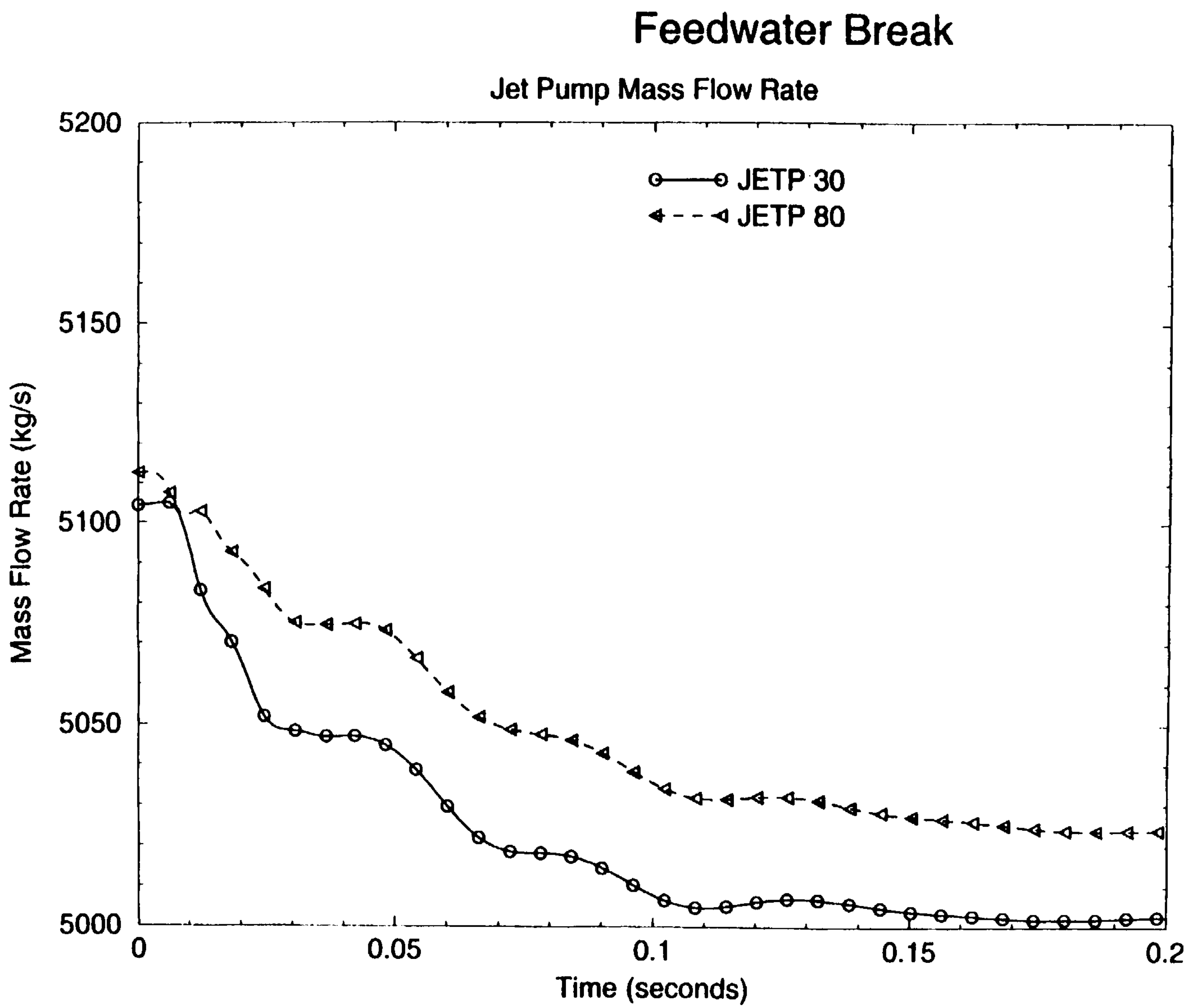


Figure 27: Mass Flow Rate in Jet Pump Components 30 and 80 (0-0.2 sec)

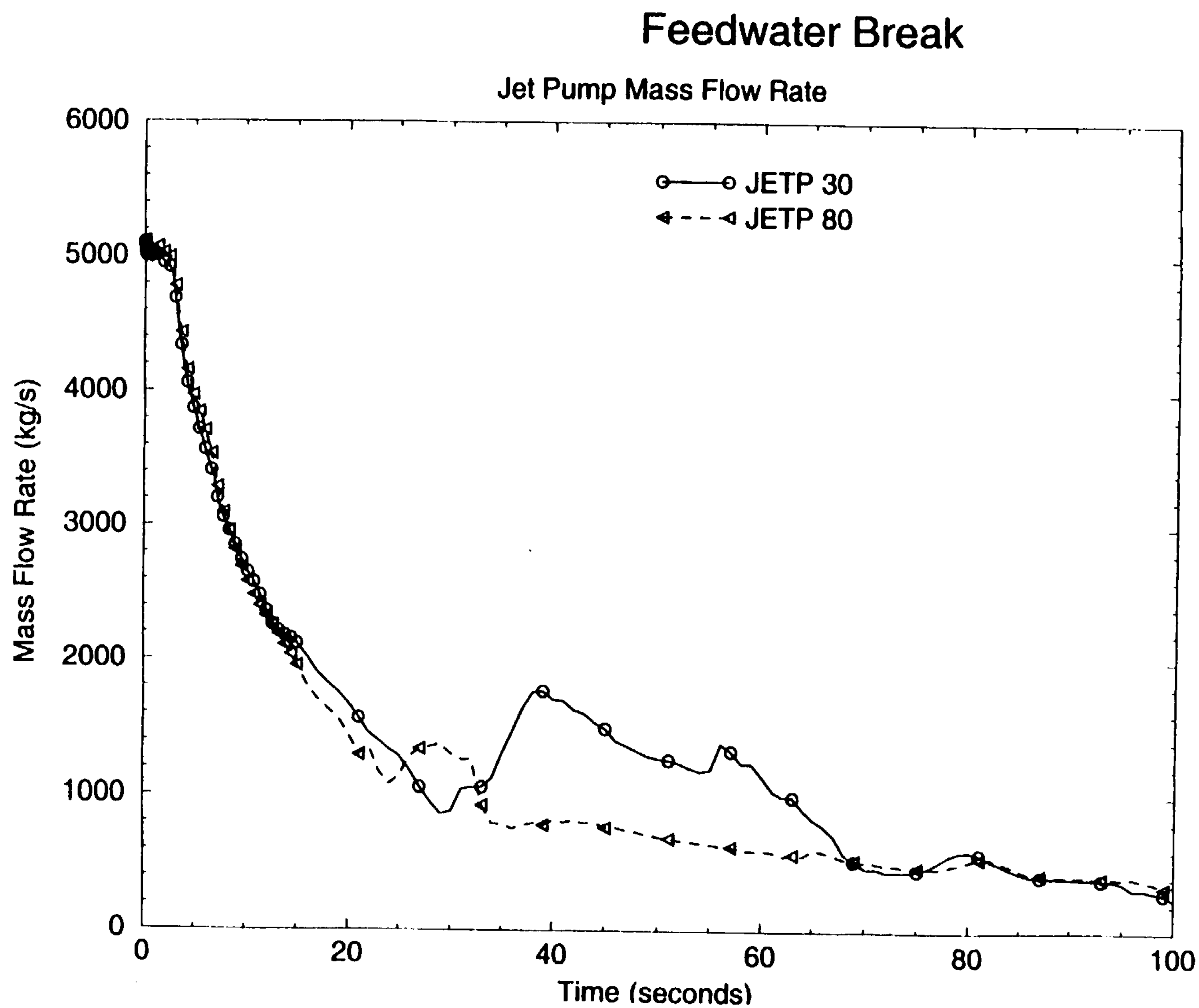


Figure 28: Mass Flow Rate in Jet Pump Components 30 and 80 (0-100 sec)

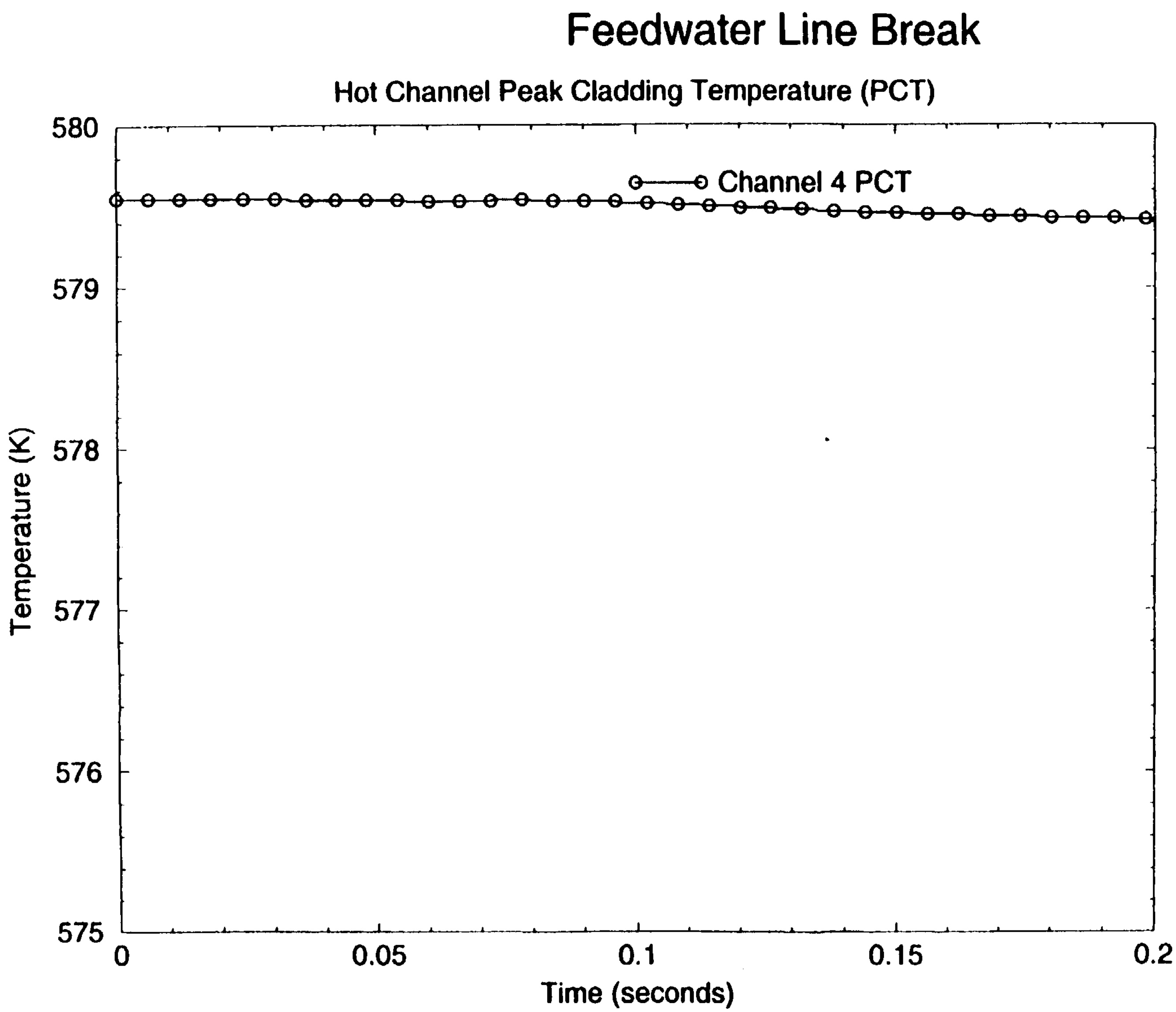


Figure 29: Peak Cladding Temperature for Hot Channel Component 4 (0-0.2 sec)

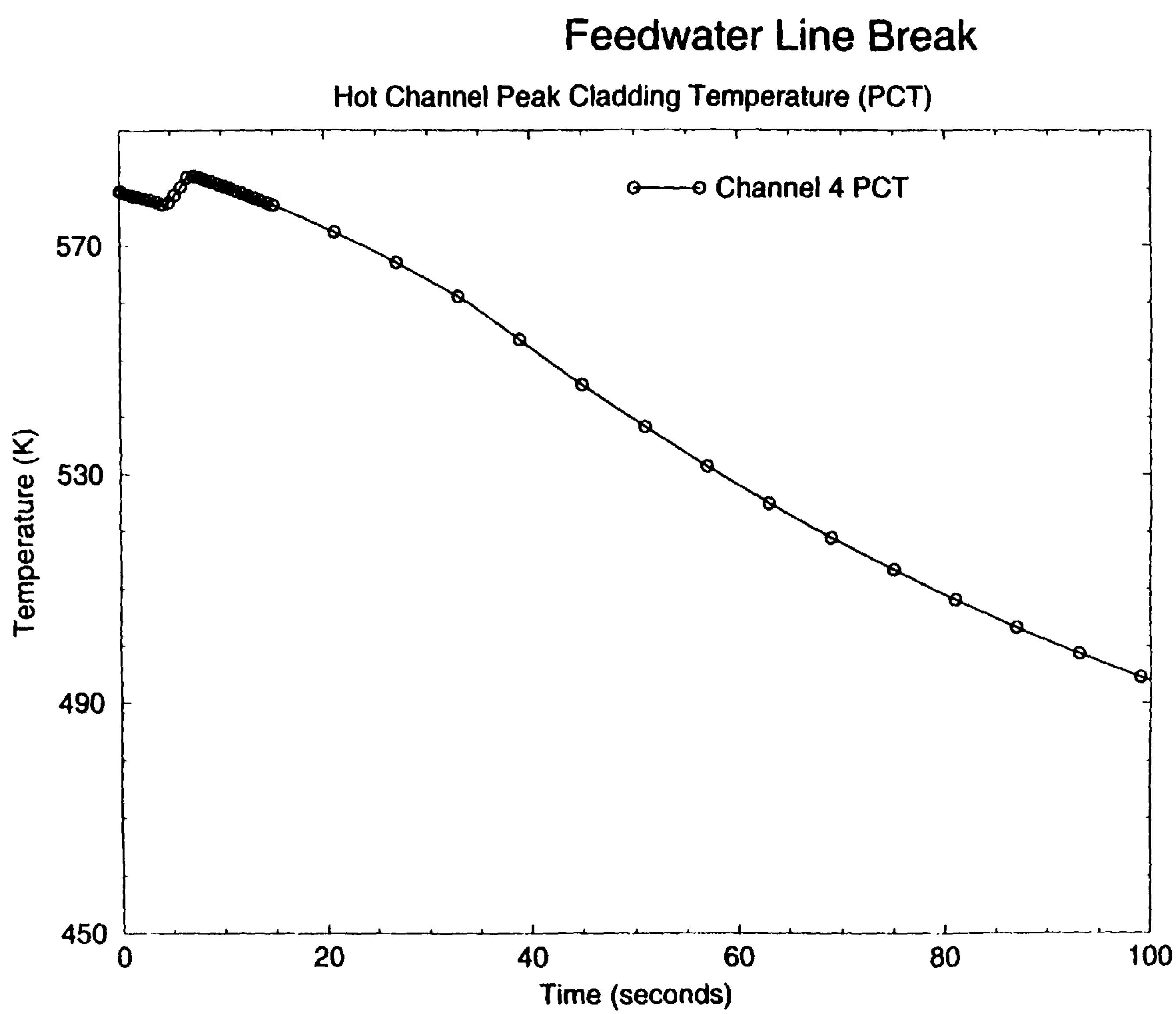


Figure 30: Peak Cladding Temperature for Hot Channel Component 4 (0-100 sec)

Feedwater Line Break

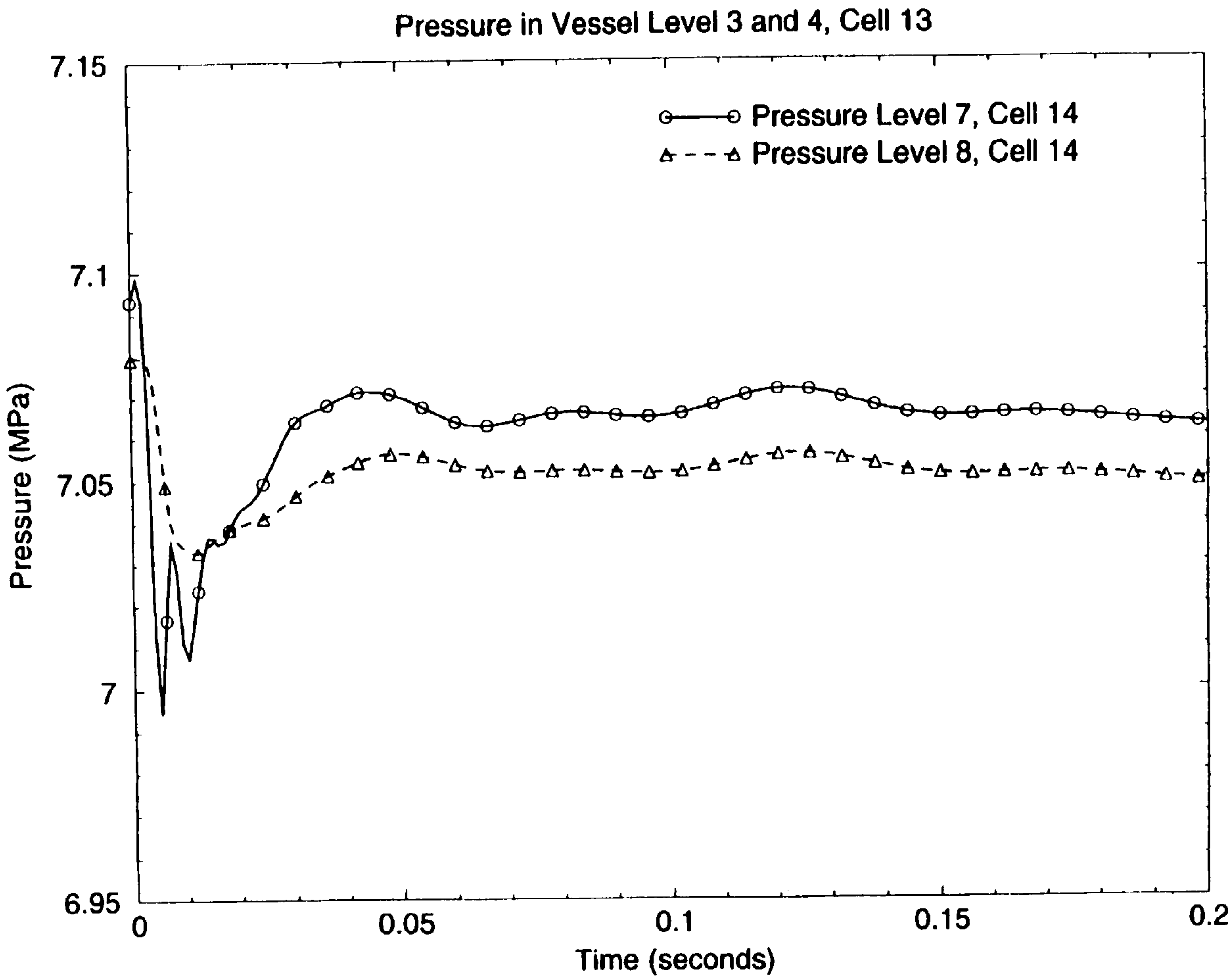


Figure 31: Pressure in Vessel Level 7, Cell 14, and Level 8 and Cell 14 (0-0.2 sec)

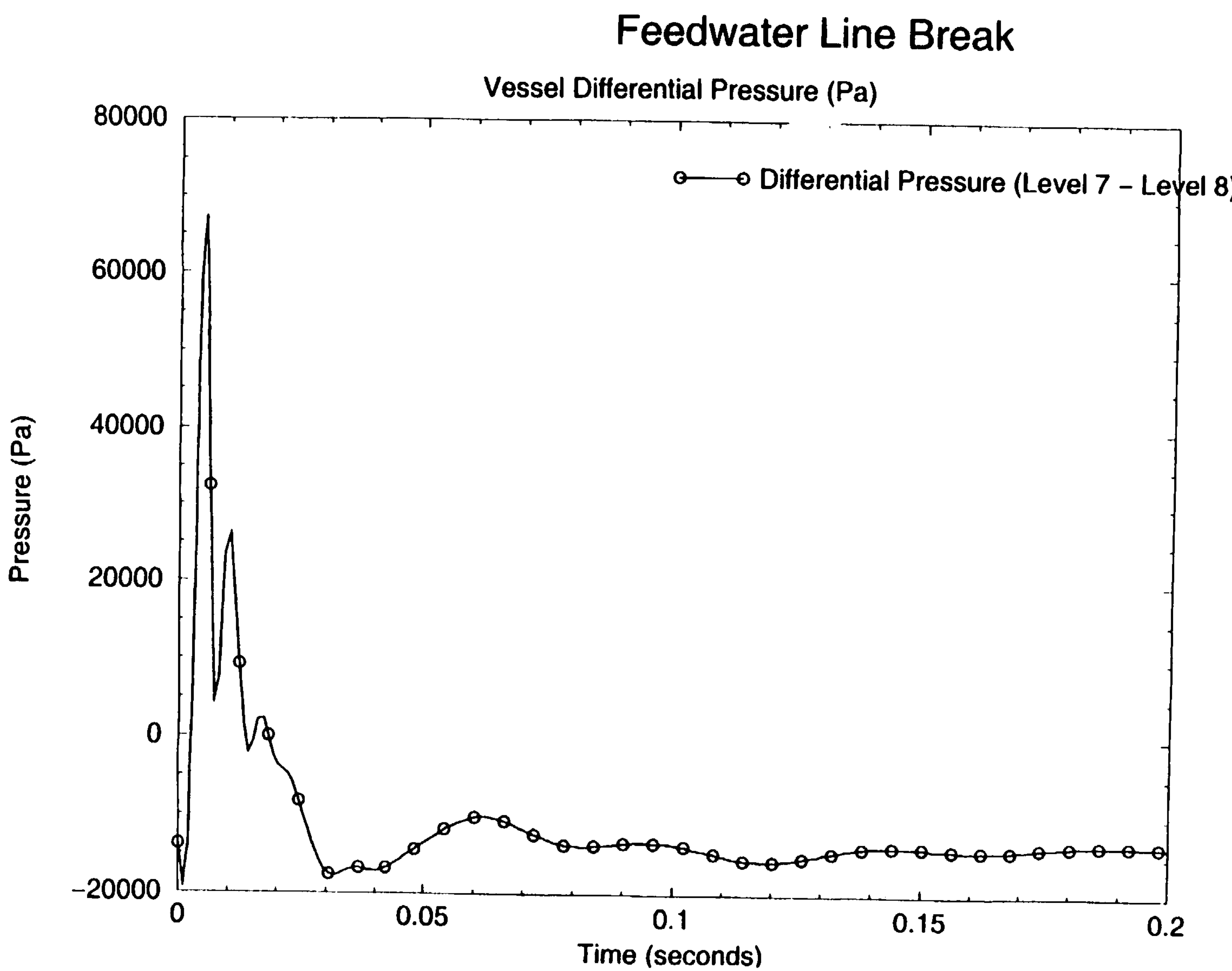


Figure 32: Differential Pressure Between Level 7 and 8 in Cell 14 (0-0.2 sec)

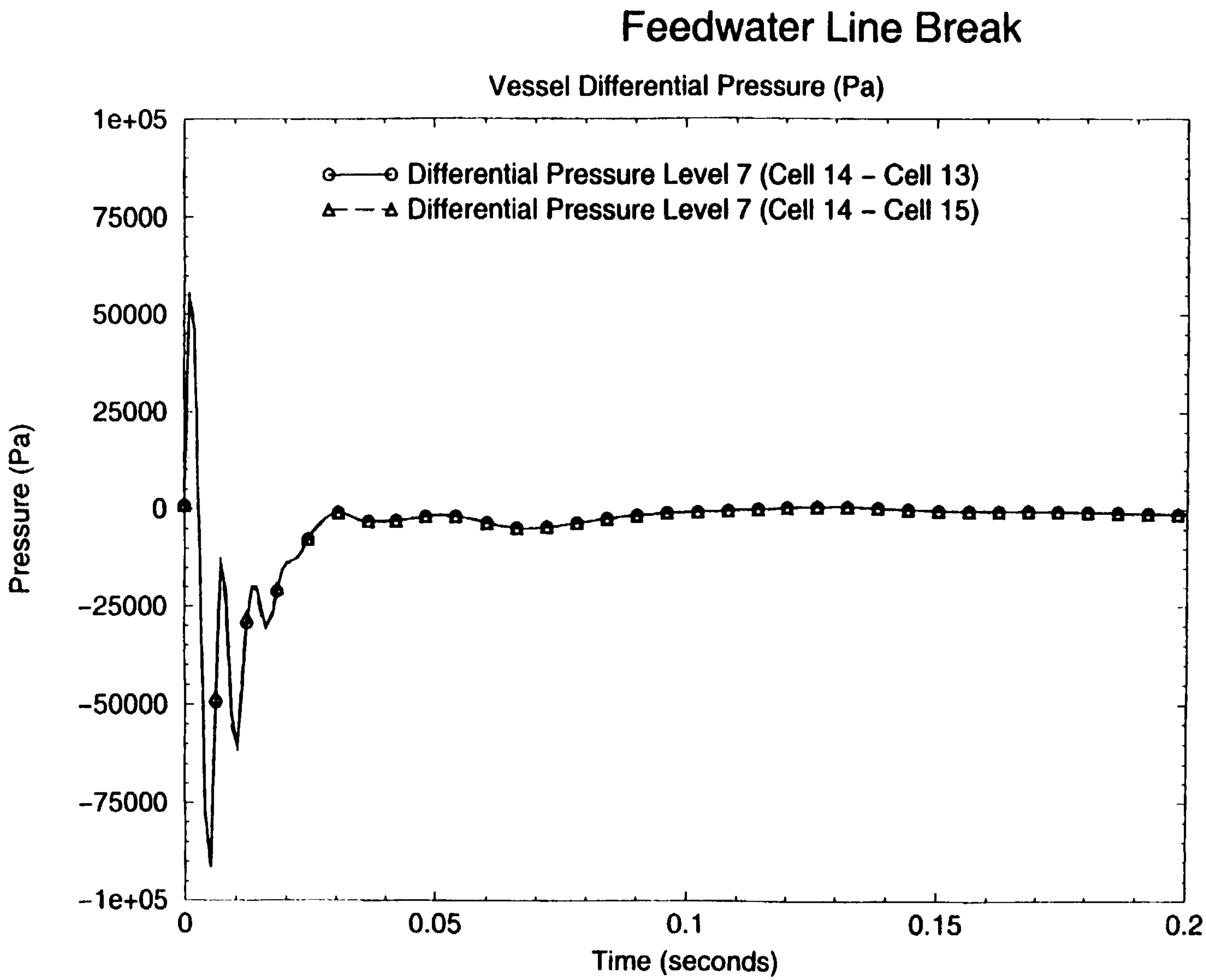


Figure 33: Differential Pressure Between Cell 14, 15 and 13 in Level 7 (0-0.2 sec)

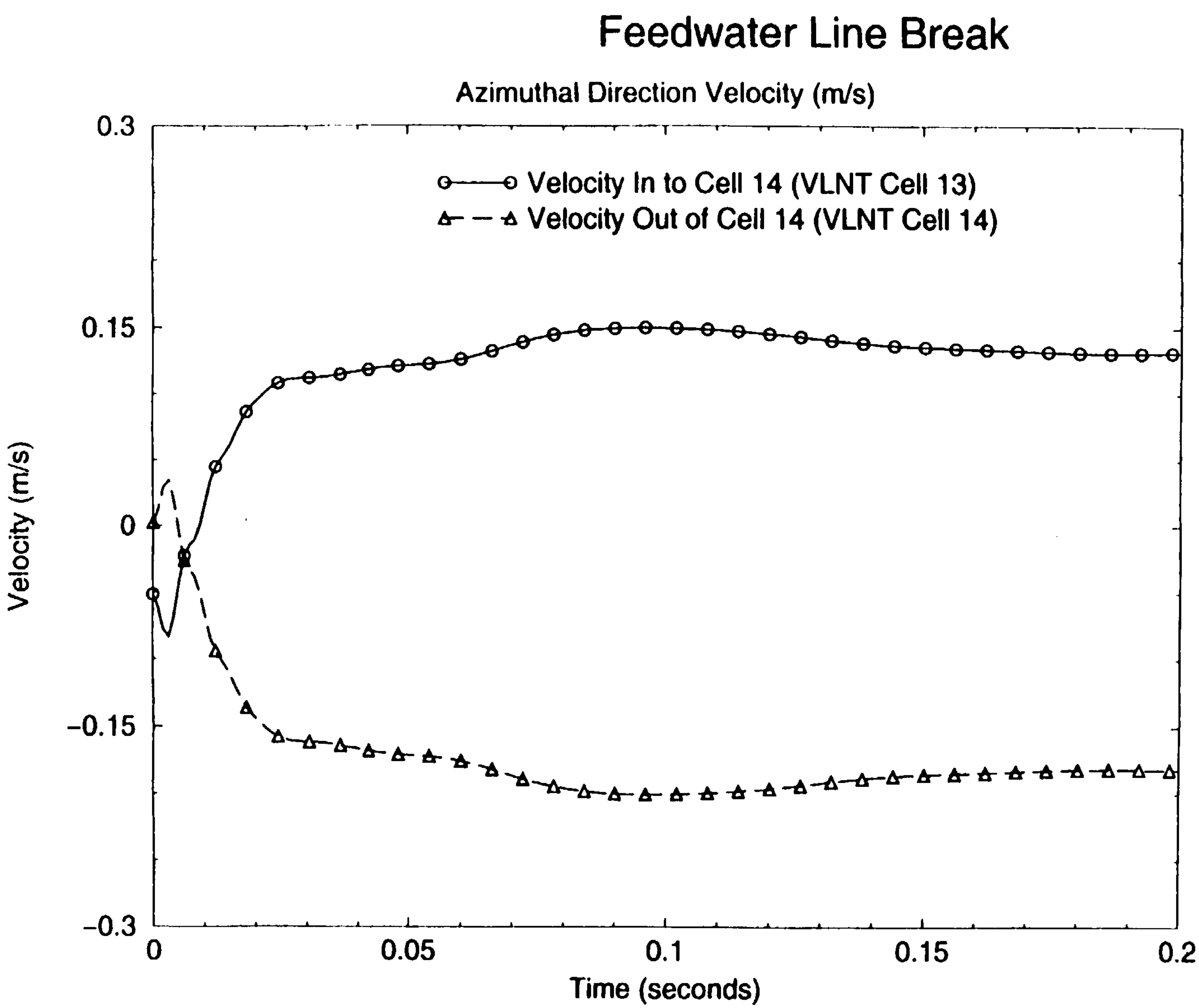


Figure 34: Azimuthal Liquid Velocities in And Out of Cell 14, Level 7 (0-0.2 sec)

Main Steam Line Break Transient Calculation for

Donald E. Palmrose and Christer Dahlgren

August 1998

SCIENTECH, Inc.
11140 Rockville Pike, Suite 500
Rockville, MD 20852

INTRODUCTION

This calculation was performed as part of the support of the BWR component failure program. The purpose of this calculation is to provide thermal and hydraulic information to support the assessment of failure of the main steam line. The assessment of BWR component failure is to be conducted by the INEEL.

The break was postulated to occur in the main steam line between a flow limiting orifice and a MSIV (see Figure 1). The break is assumed to occur during normal operation and to be a double-guillotine break. The break in the main steam line will cause steam to exit the vessel through two paths, directly from the vessel via the affected main steam line and indirectly through the other three MSIVs, through the common header and out the affected MSIV. The three unaffected main steam lines were lumped into one common steam line as shown in Figure 1.

The purpose of this calculation is to provide the boundary conditions for failure calculations on the affected components. The results of this calculation are presented below in the discussion section. A summary of the results and concluding remarks are presented in the conclusion section.

The following parameters are presented in Figure 2 to 12:

System Parameters:
Total Reactor Power (Figure 2)
Steam Dome Pressure (Figure 3)
Steam Lines and Feedwater Mass Flow Rates (Figure 4)
Recirculation Pump 1 and 2 Mass Flow Rates (Figure 5)
Hot Channel Peak Cladding Temperature (Figure 6)

Break Parameters:
Mass Flow Rate on the Inboard Side of the Break (Figure 7)
Liquid and Vapor Velocities on the Inboard Side of the Break (Figure 8)
Pressure on the Inboard Side of the Break (Figure 9)
Mass Flow Rate on the Outboard Side of the Break (Figure 10)
Liquid and Vapor Velocities on the Outboard Side of the Break (Figure 11)
Pressure on the Outboard Side of the Break (Figure 12)

All break and system parameters have been plotted over the duration of the calculation (100 seconds). The results show the system properties moving to a quasi-steady operational state after 100 seconds. The first 0.20-sec of the transient was calculated using a time step of 0.001 sec. This time step was based on the sonic courant limit for the cell upstream of the break location. The courant limit for this cell is:

$$\Delta x/u_{sonic} = 1.16/1100 \text{ sec} = 0.00105 \text{ sec}$$

This time step was necessary to capture the decrease in pressure in the vessel. Every calculated time step is plotted, but for reasons of clarity, a symbol is only attached to every tenth data point.

The remainder of the transient was calculated using a maximum time step of 0.01 sec. The courant limit was much lower than this for the remainder of the transient. The courant limit for the major part of the calculation was 0.004 sec. The courant limit time step was limited by component 56, which has the unisolatable break.

DISCUSSION

This section will discuss results of the calculation and the changes in the key parameters during this transient.

Figure 1 is simplified diagrams of the main steam lines with the break components.

There are two major events during this transient. The first is a low-level trip at approximately 21 seconds. This is followed by the full closing of the MSIVs by 24 seconds.

A summary of the key break and vessel parameters follows in the conclusion section. The key parameters are presented in Figures 2 to 12.

CONCLUSIONS

This main steam line break calculation was performed in the support of the BWR component failure program. The transient calculation showed the following changes in the key parameters:

Break and Vessel Pressure: The system pressure continuously decreases from 7.1 MPa to 1.5 -1.8 MPa over the entire transient (see Figures 3, 9 and 12).

Break Mass Flow Rate: An instantaneous increase to 2000 kg/s from each end of the double-guillotine breaks is observed (see Figures 7 and 10). Once the initial blowdown and completion of MSIV closure, the break mass flow rate slowly decreases in a manner comparable to the system pressure.

Break Velocity: The velocity of each end of the break are shown in Figures 8 and 11. After the initial jump to about 600 m/s, the unisolable break velocity oscillates between 300 to 500 m/s. The isolable break velocity shows a similar response in the first 20 seconds but rapidly decreases to zero with MSIV closure.(see Figure 11).

The appropriate parameter data will be supplied to the INEEL at their request.

Figure 1. Simplified Main Steam Break Nodalization

Figure 2. Total Reactor Power

Figure 3. Steam Dome Pressure

Figure 4. Steam Lines and Feedwater Mass Flow Rates

Figure 5. Recirculation Pump Mass Flow Rates

Figure 6. Hot Channel Peak Cladding Temperature (PCT)

Figure 7. Mass Flow Rate on the Inboard Side of the Break

Figure 8. Liquid and Vapor Velocities on the Inboard Side of the Break

Figure 9. Pressure on the Inboard Side of the Break

Figure 10. Mass Flow Rate on the Outboard Side of the Break

Figure 11. Liquid and Vapor Velocities on the Outboard Side of the Break

Figure 12. Pressure on the Outboard Side of the Break

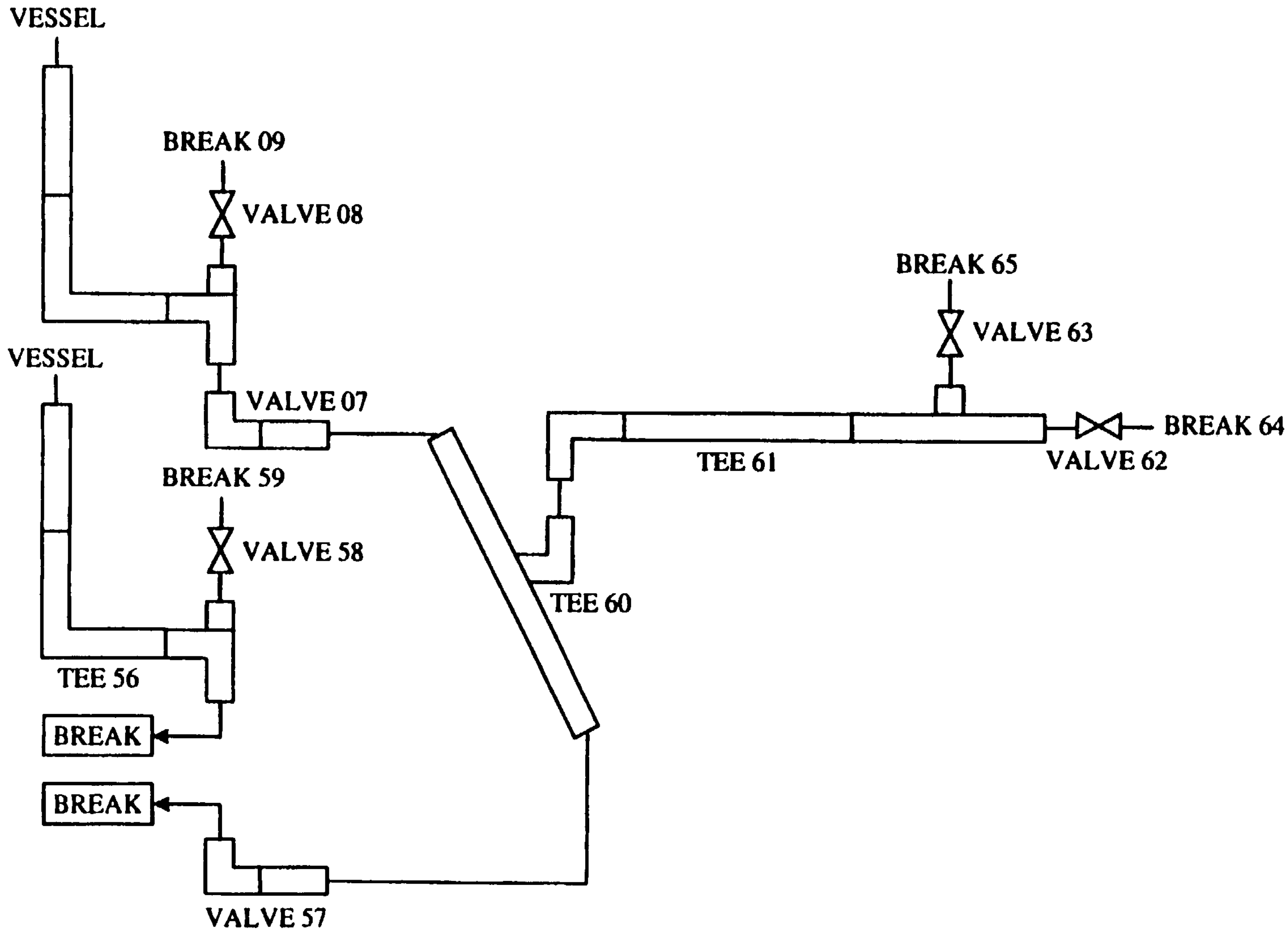
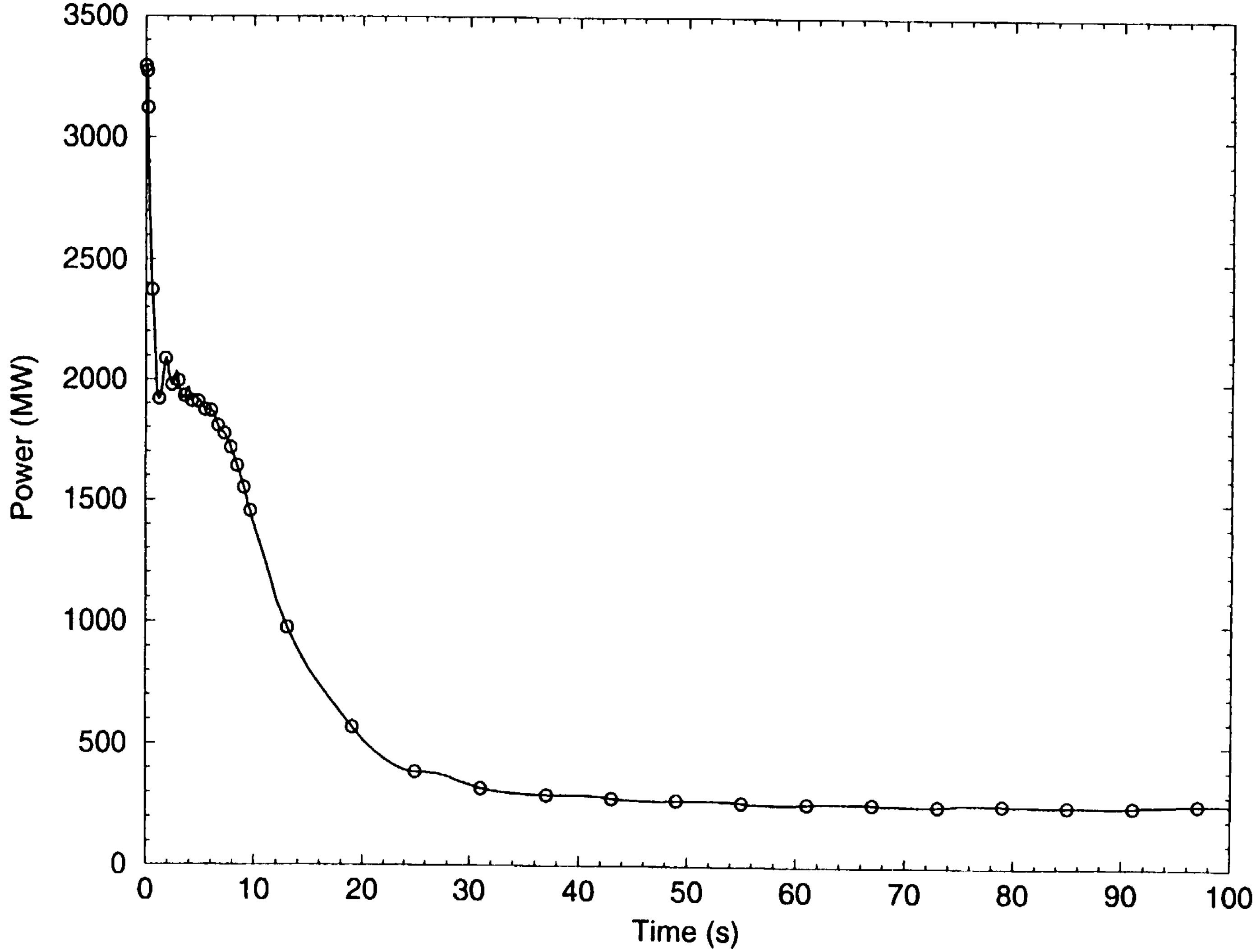


FIGURE 1. MAIN STEAM LINE BREAK NODALIZATION

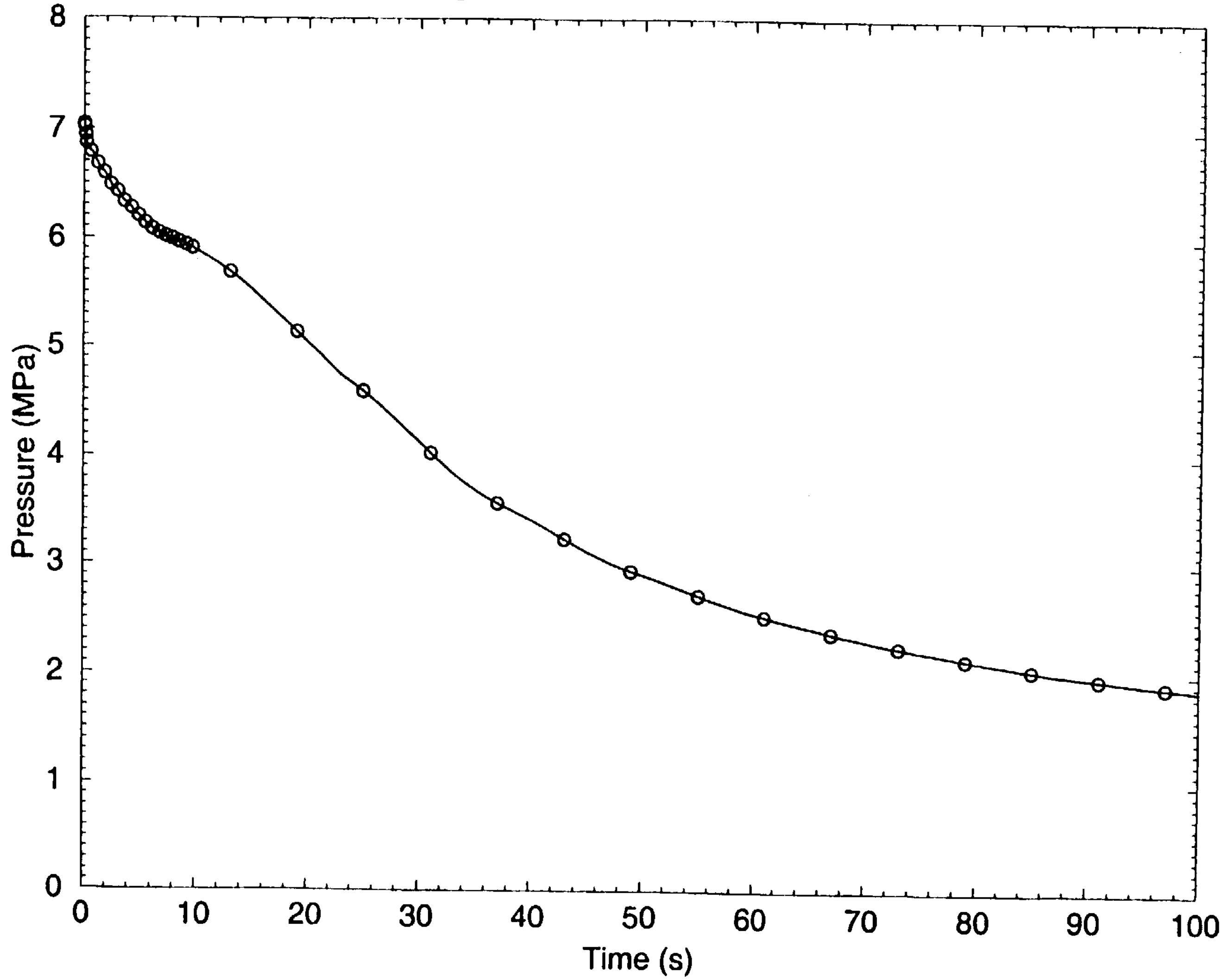
Main Steam Line Break

Figure 2. Total Reactor Power



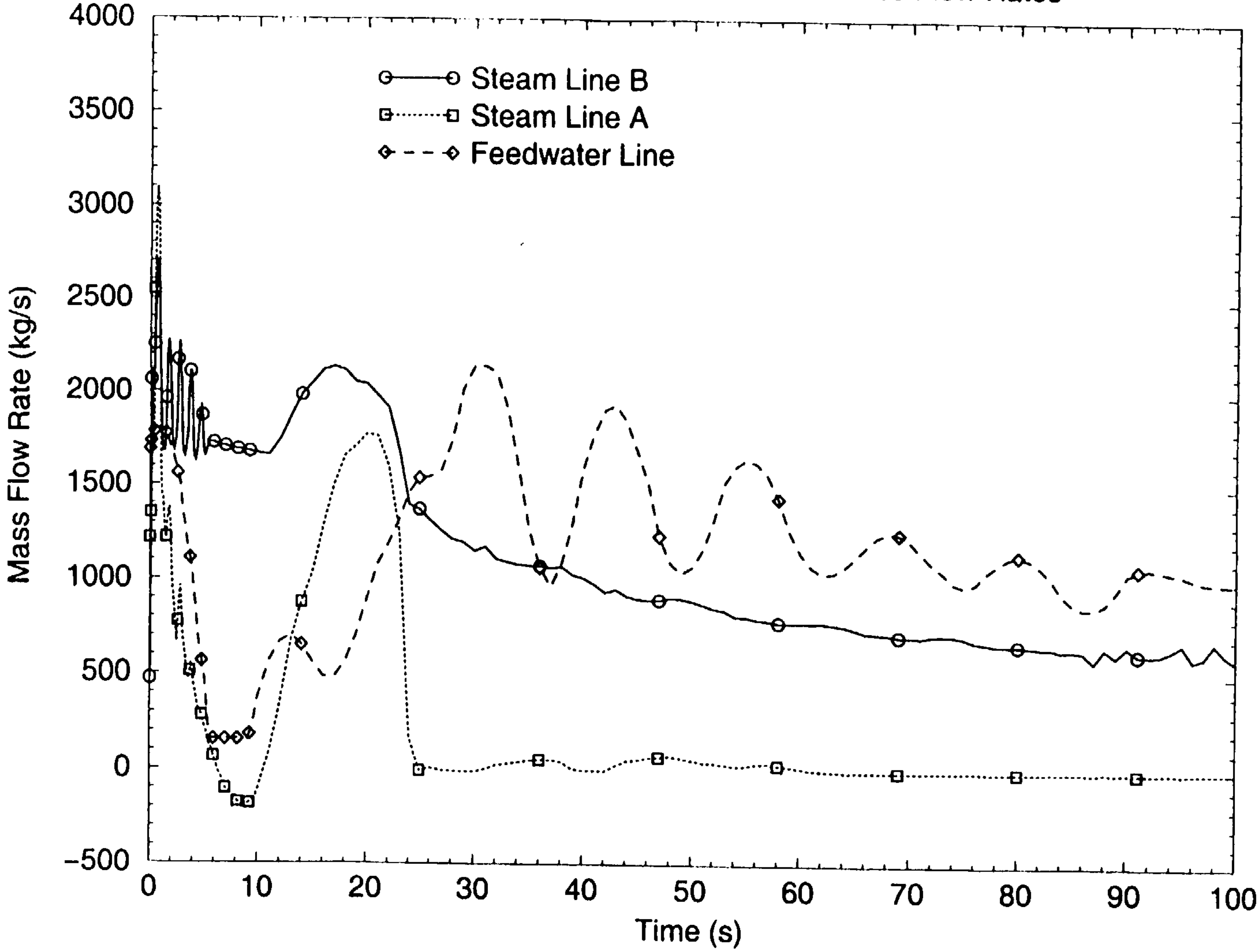
Main Steam Line Break

Figure 3. Steam Dome Pressure



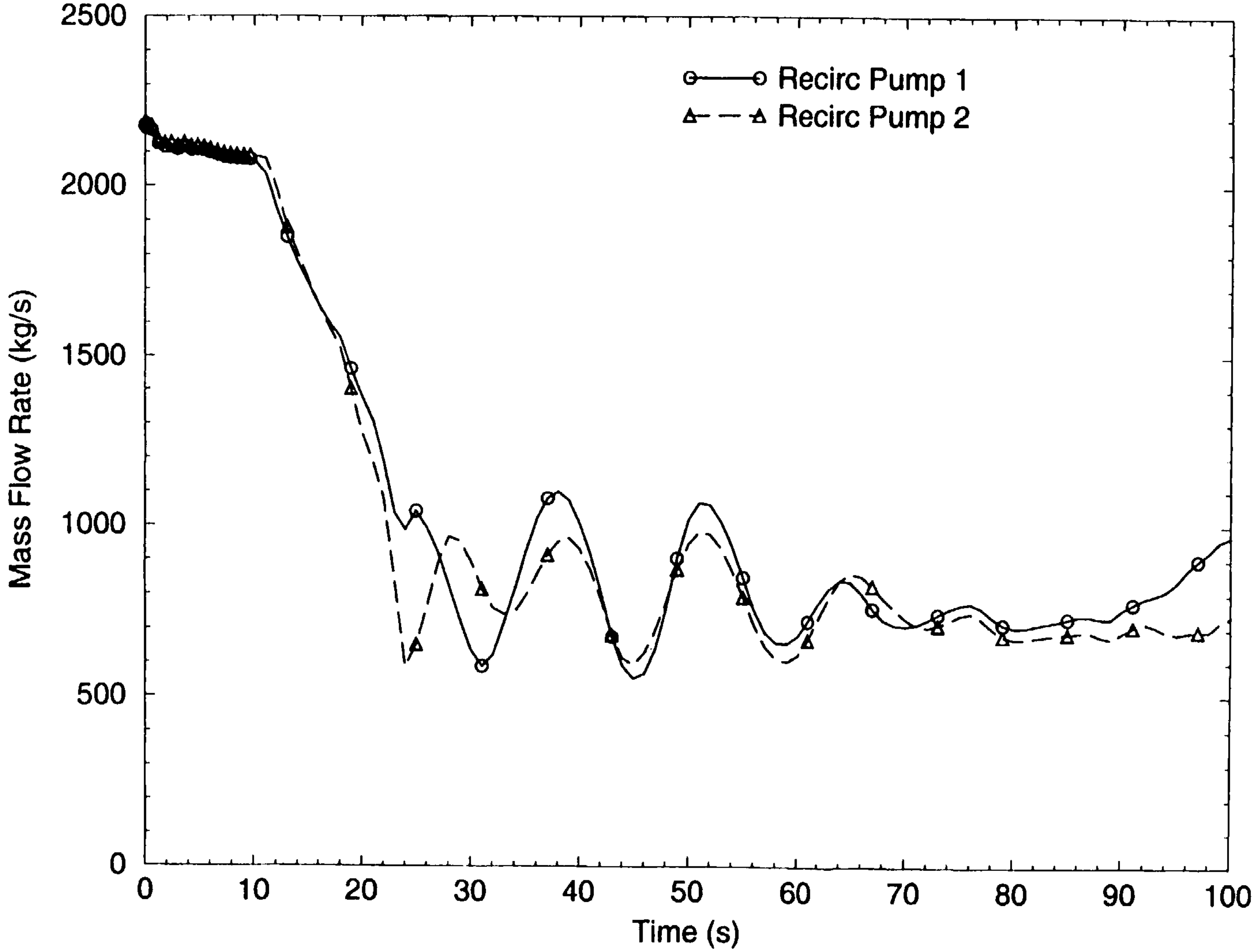
Main Steam Line Break

Figure 4. Steam Lines and Feedwater Mass Flow Rates



Main Steam Line Break

Figure 5. Recirculation Pump Mass Flow Rates



Main Steam Line Break

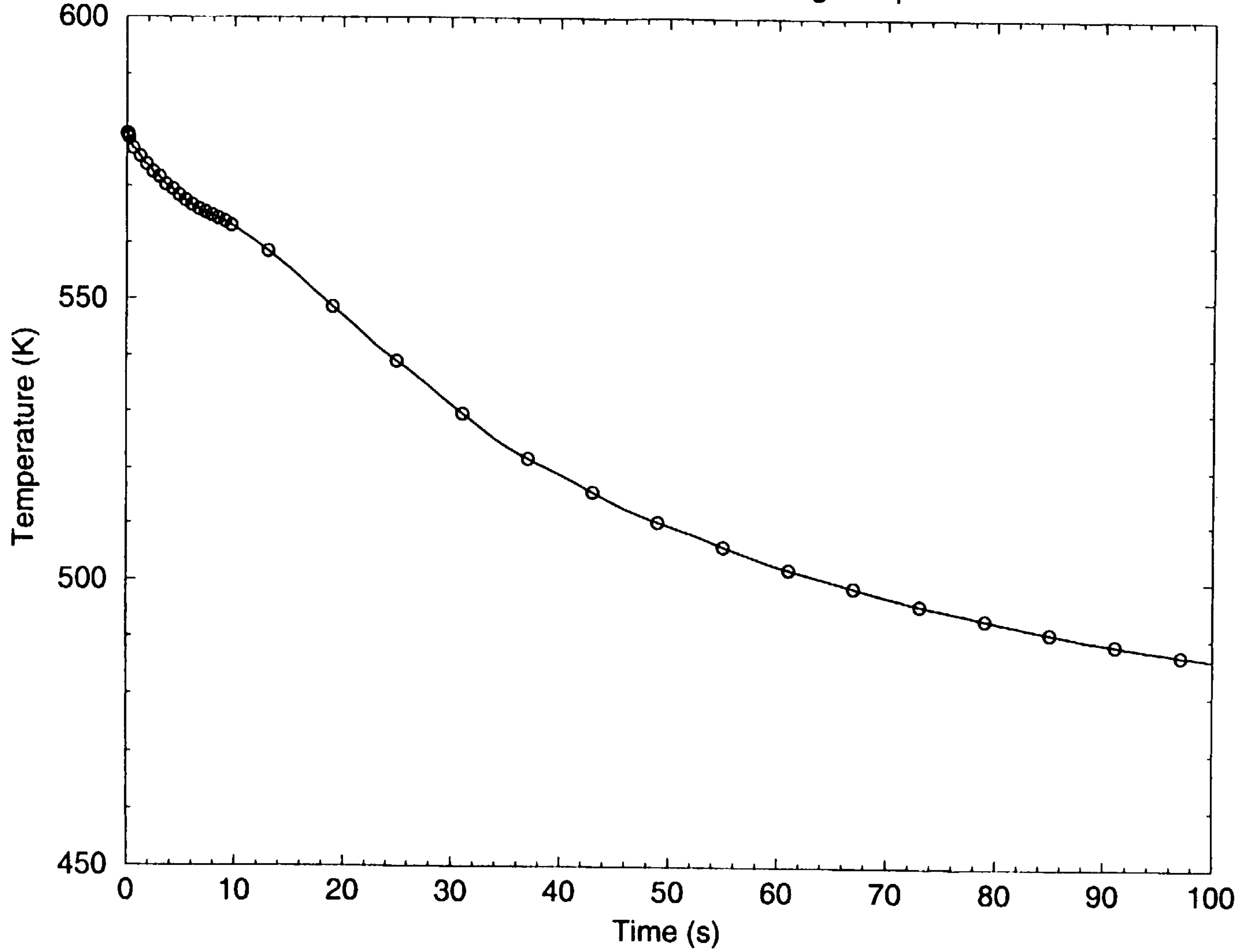
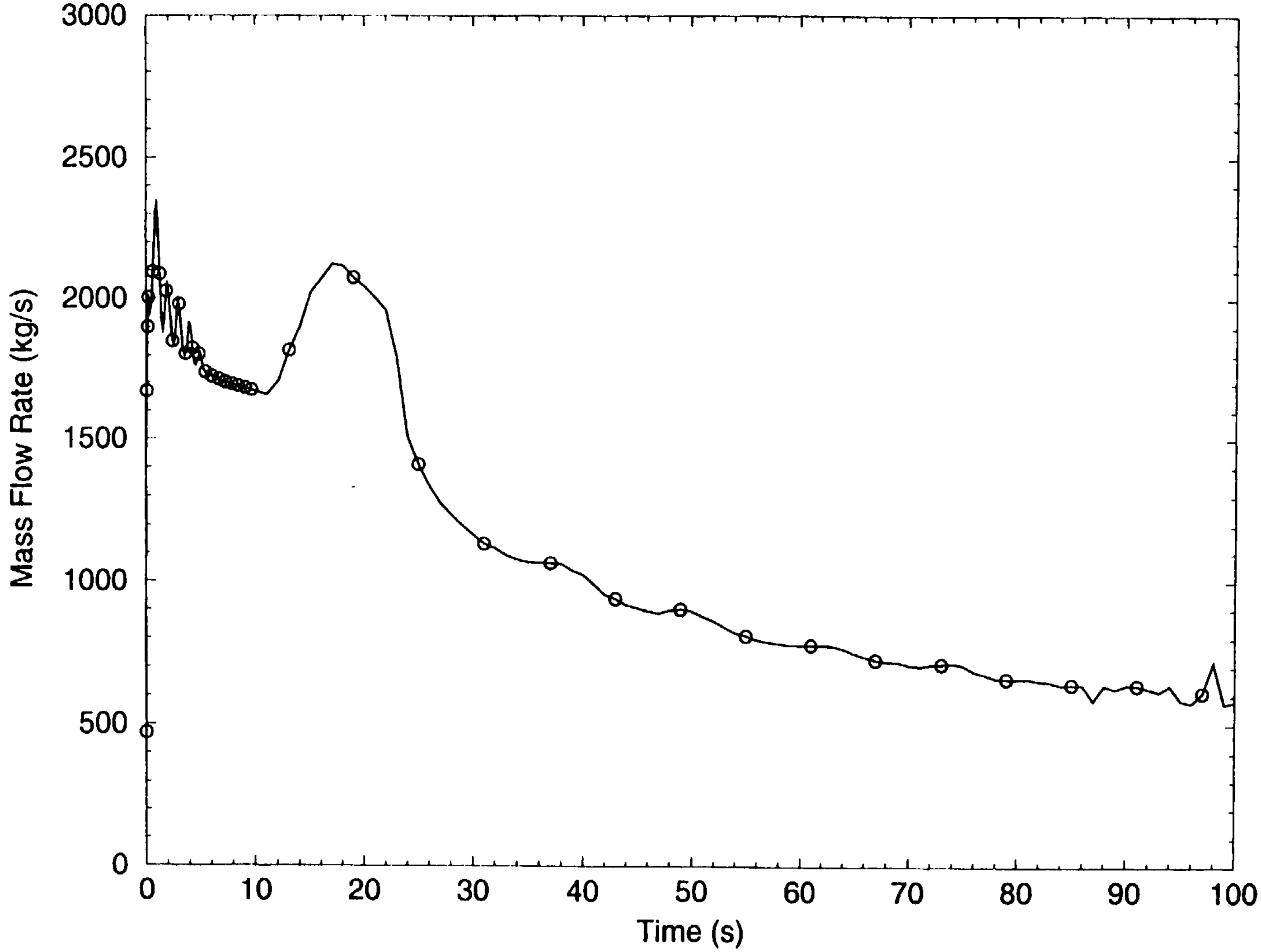


Figure 6. Hot Channel Peak Cladding Temperature

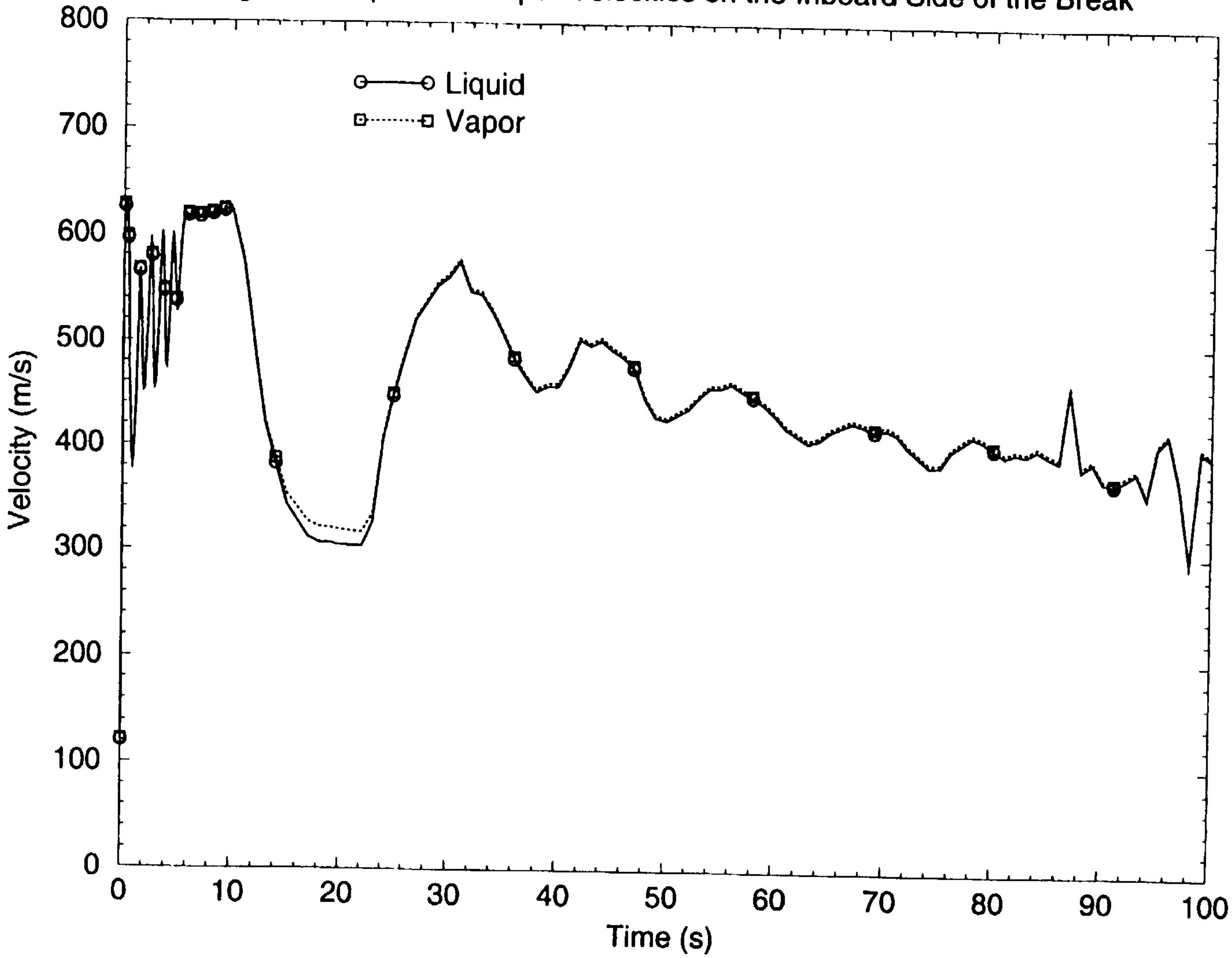
Main Steam Line Break

Figure 7. Mass Flow Rate on the Inboard Side of the Break



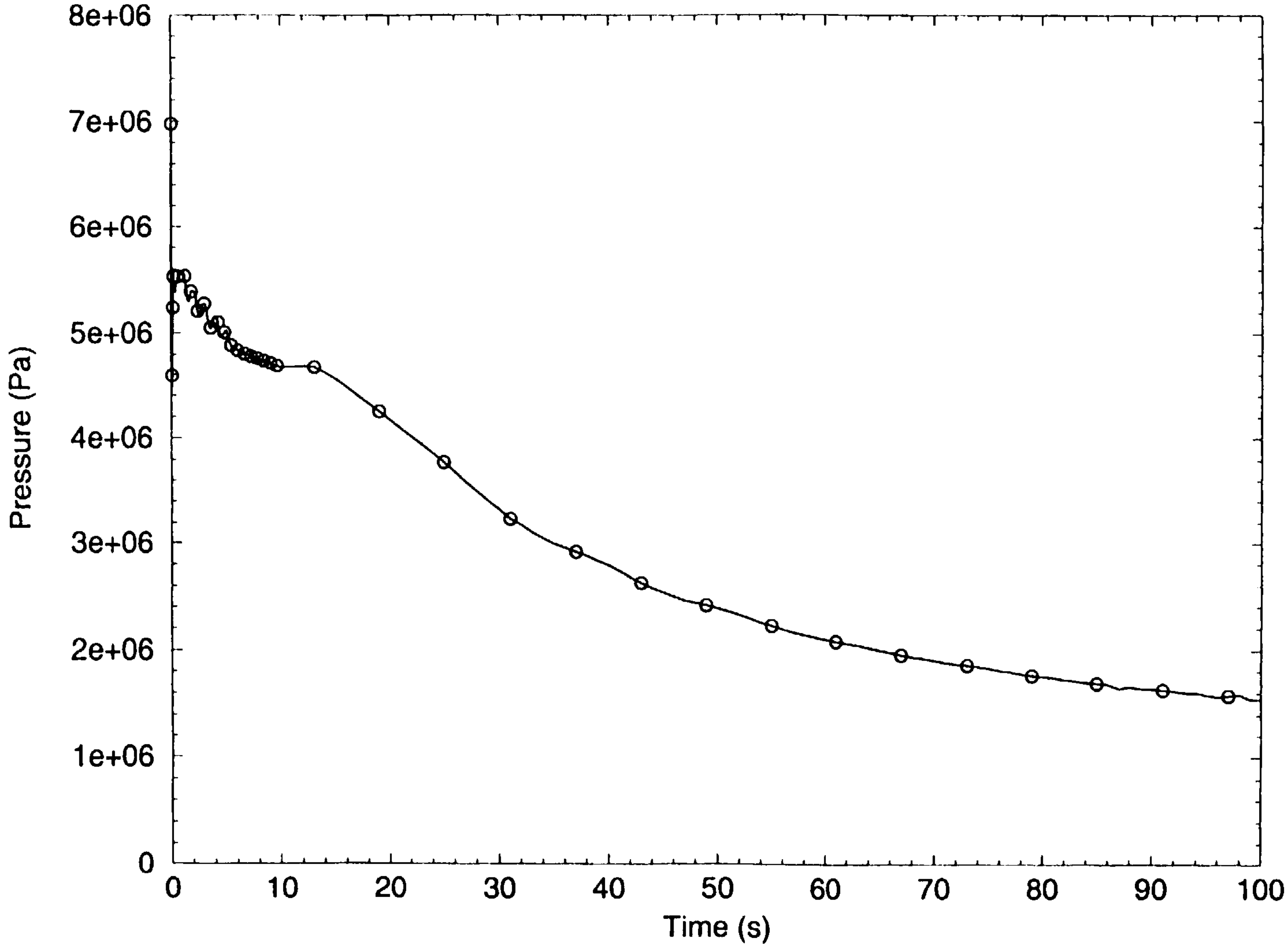
Main Steam Line Break

Figure 8. Liquid and Vapor Velocities on the Inboard Side of the Break



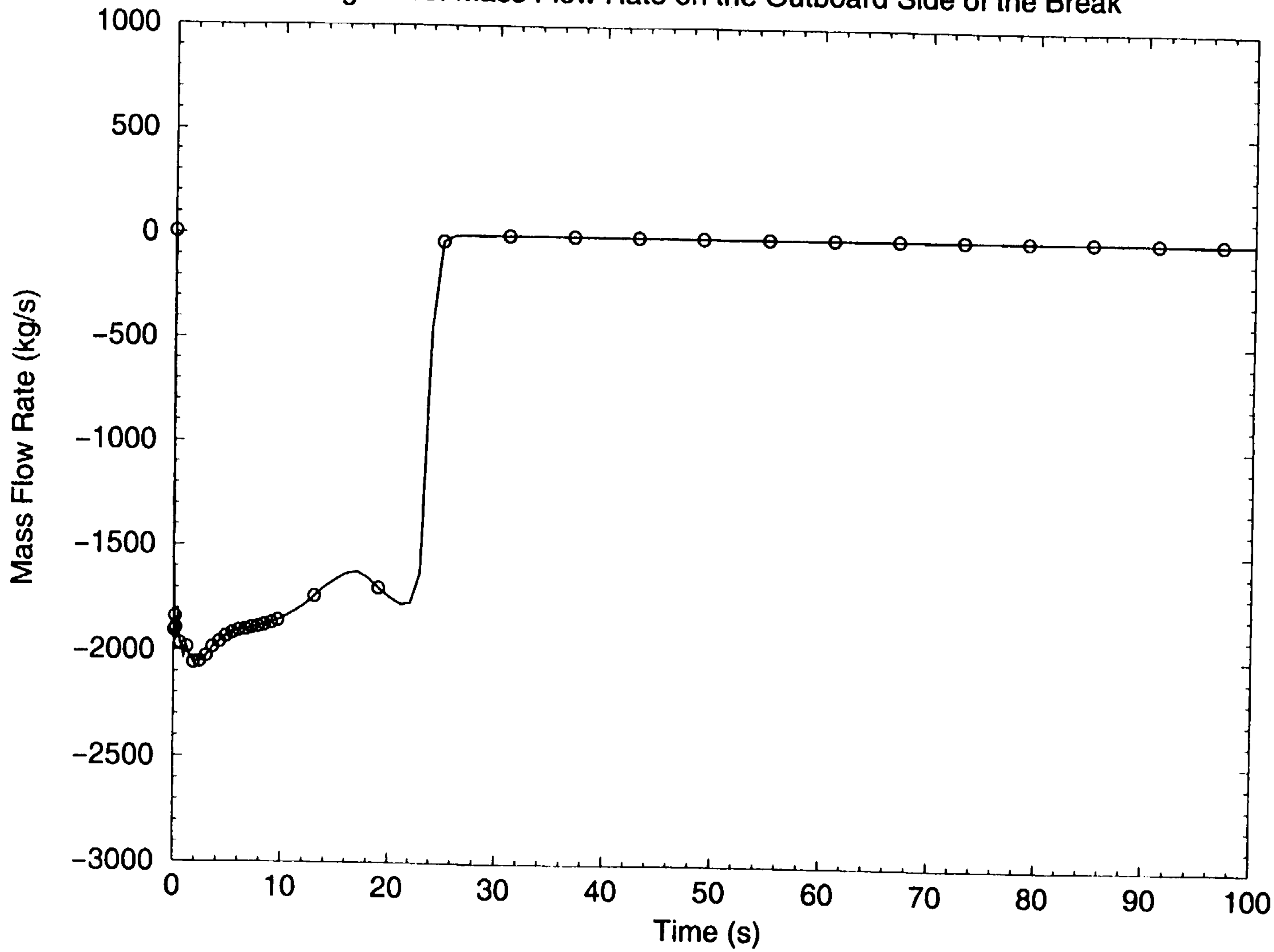
Main Steam Line Break

Figure 9. Pressure on the Inboard Side of the Break



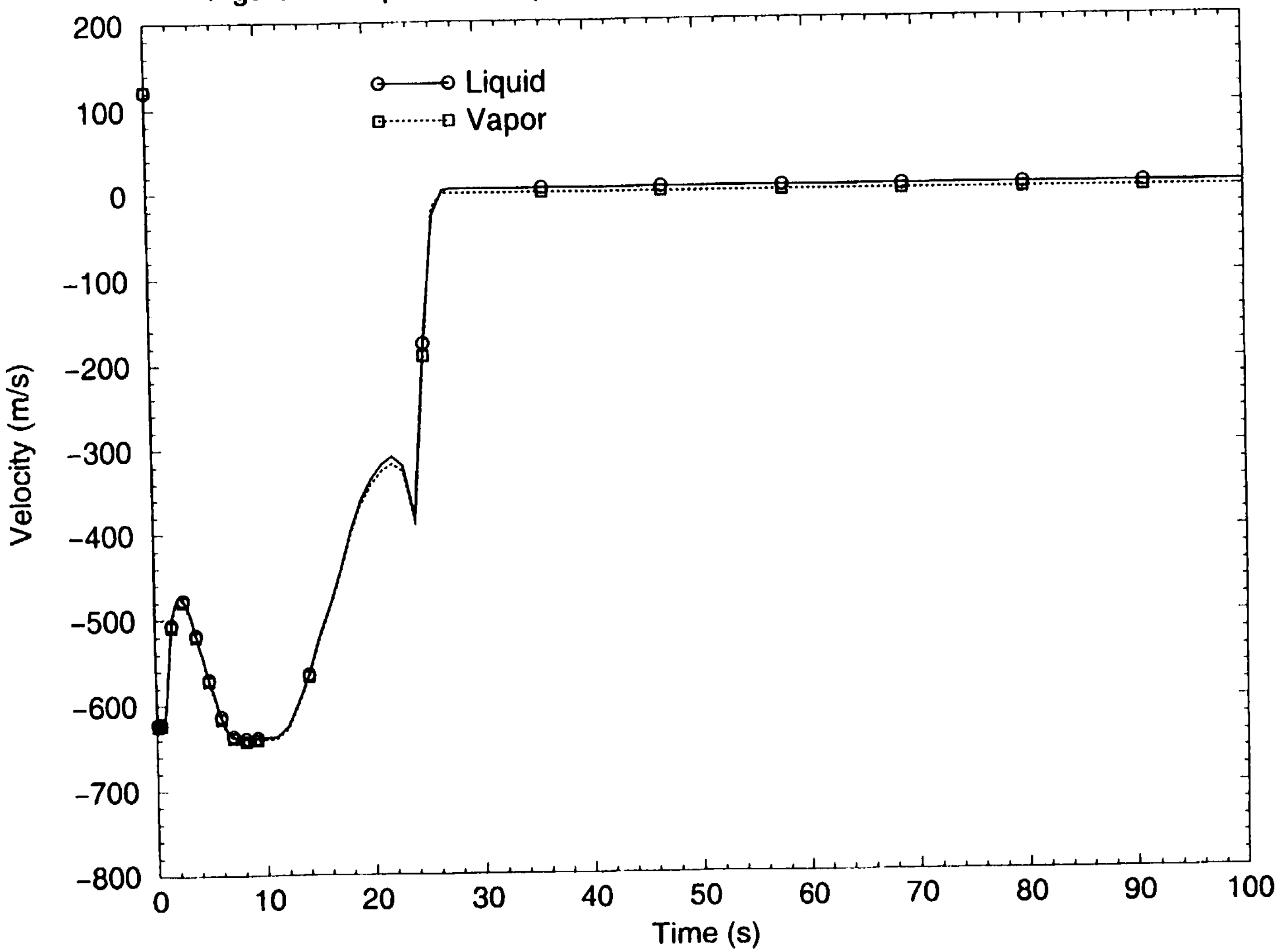
Main Steam Line Break

Figure 10. Mass Flow Rate on the Outboard Side of the Break



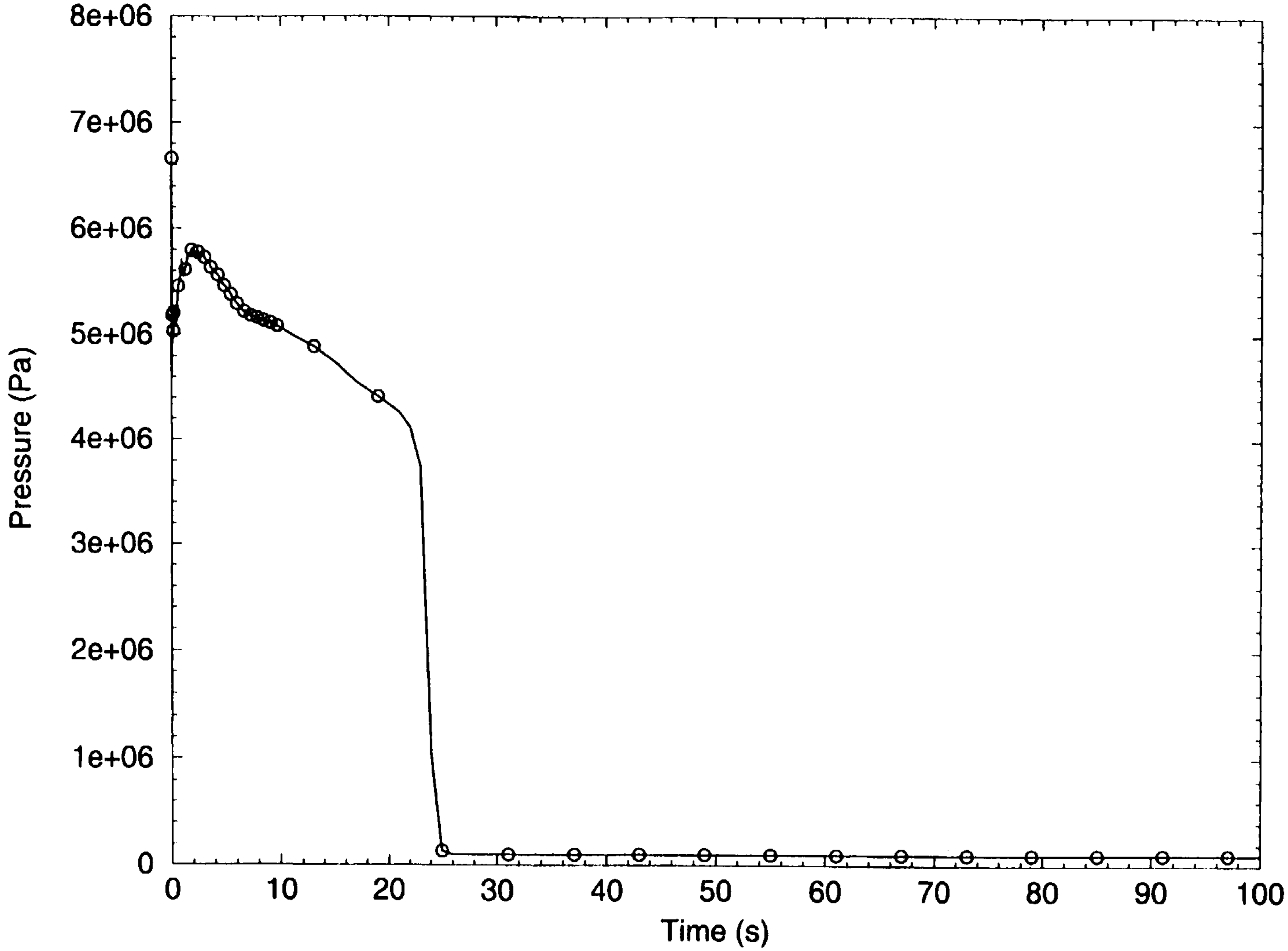
Main Steam Line Break

Figure 11. Liquid and Vapor Velocities on the Outboard Side of the Break



Main Steam Line Break

Figure 12. Pressure on the Outboard Side of the Break



NRC FORM 335 (2-89) NRCM 1102, 3201, 3202 U.S. NUCLEAR REGULATORY COMMISSION **BIBLIOGRAPHIC DATA SHEET** *(See instructions on the reverse)*	1. REPORT NUMBER (Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.) NUREG/CR-6677
2. TITLE AND SUBTITLE Evaluation of Risk Associated With Intergranular Stress Corrosion Cracking in B oiling Water Reactor Internals	3. DATE REPORT PUBLISHED MONTH: July YEAR: 2000 4. FIN OR GRANT NUMBER W6529
5. AUTHOR(S) A.G. Ware, D.K. Morton, M.E. Nitzel, S.A. Eide	6. TYPE OF REPORT Final 7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC
Idaho Falls, Idaho 83415-3129

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Division of Engineering Technology
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

NRC Project Manager: T.Y. Chang

11. ABSTRACT *(200 words or less)*

Intergranular stress corrosion cracking (IGSCC) has been detected in a number o f Boiling Water Reactor (BWR) vessel internals. The number of different types of components that have experienced c racking has increased over the years. Based on evaluations submitted by General Electric, BWR owners, and the BWR Vessel an d Internals Project (BWRVIP) group, the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission has d etermined that the short-term risk significance of cracking of BWR vessel internals is acceptable. The purpose of this report is to evaluate the long-term risk associated with IGSCC of BWR vessel internals. The differences in BWR types we re studied, the history of IGSCC in reactor internals was catalogued, and tables of accident scenarios involving cracked in ternals were developed. Screening methods were developed to reduce the number of accident scenarios that represent more s ignificant risk to a more manageable number, and a final list of potential concerns was developed which ranked the s cenarios as having a high, medium, or low impact on increasing the core damage frequency (CDF) based on a qualitative ris k assessment. In order to narrow the scope of the problem, the investigation was limited to a single BWR type (high-energy BWR/4). Using several screening methods, the scenarios to investigate were reduced by about 2/3. To further concentrate the investigation and develop a methodology to be used, scenarios resulting from the failure of a single component (jet pump) were evaluated. The evaluation was then extended to the remaining reactor internals components. It was concluded that with the current BWRVIP inspection, monitoring, and repair proposals, there is expected to be no significant increa se in CDF (<5 E-6 events/yr) caused by failures of BWR internals. That is, IGSCC problems can be identified and evaluated or co rrected, to preclude a significant increase in the CDF.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)* Boiling Water Reactor (BWR), BWR Vessel Internals, Intergranular Stress Corrosi on Cracking (IGSCC), Risk, accident scenarios, Core Damage Frequency (CDF), inspection, mon itoring, repair	13. AVAILABILITY STATEMENT unlimited 14. SECURITY CLASSIFICATION *(This Page)* unclassified *(This Report)* unclassified 15. NUMBER OF PAGES 16. PRICE

Printed on recycled paper

Federal Recycling Program

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

1975 25 2000
years