ASSESSMENT OF CONSERVATISM IN THE 1981 WESTINGHOUSE LARGE BREAK LOCA EVALUATION MODEL WITH BASH

PRESENTATION TO USNRC
MARCH 6, 2001

RICHARD R. SCHOFF
WESTINGHOUSE ELECTRIC COMPANY, LLC
(412) 374-5685

PURPOSE

TO ASSESS THE CONSERVATISM THAT EXISTS IN THE 1981 WESTINGHOUSE LARGE BREAK LOCA (LBLOCA) EVALUATION MODEL WITH BASH (BASH-EM), IN RESPONSE TO THE REQUEST ISSUED BY THE USNRC

1. BASH-EM CODE STREAM

- MAIN CODES ARE SATAN-VI, BASH, AND LOCBART
    - SATAN-VI CALCULATES THE RCS BLOWDOWN THERMAL-HYDRAULIC TRANSIENT
    - BASH CALCULATES THE RCS REFILL AND REFLOOD THERMAL-HYDRAULIC TRANSIENTS
    - LOCBART CALCULATES THE HOT ASSEMBLY AND HOT ROD CLADDING HEATUP FOR ALL THREE PHASES OF THE LBLOCA TRANSIENT
- BASH CREATED BY MERGING THE BART-A1 CORE HEAT TRANSFER CODE WITH A VERSION OF THE NOTRUMP SYSTEM THERMAL-HYDRAULIC CODE
- LOCBART CREATED BY MERGING THE BART-A1 CORE HEAT TRANSFER CODE WITH THE LOCTA-IV FUEL ROD CONDUCTION CODE

2. LOCBART VALIDATION AGAINST EXPERIMENTS

- LOCBART UPDATED IN 1992 TO CORRECT LOGIC ERROR IN SPACER GRID HEAT TRANSFER MODEL

- CORRECTED CODE BENCHMARKED AGAINST 12 ROD BUNDLE REFLOOD HEAT TRANSFER EXPERIMENTS (WCAP-10484-P-A ADDENDUM 1)

    - FLECHT SEASET (5 TESTS)

    - FLECHT COSINE (4 TESTS)

    - G2 (3 TESTS)

- FOR SIMPLE EGG-CRATE GRIDS (FLECHT), CORRECTED MODEL PREDICTED PCTs NEAR THE MEAN OF THE DATA, WITH A SLIGHTLY CONSERVATIVE CAPTURE FRACTION

- FOR PRODUCTION-TYPE MIXING VANE GRIDS (G2), MODEL BOUNDED NEARLY ALL OF THE DATA (FIGURES 1-4)

    - HEAT TRANSFER BENEFIT OF MIXING VANES EVIDENT IN TESTS BUT NOT FULLY REALIZED BY THE MODEL

FIGURE 1

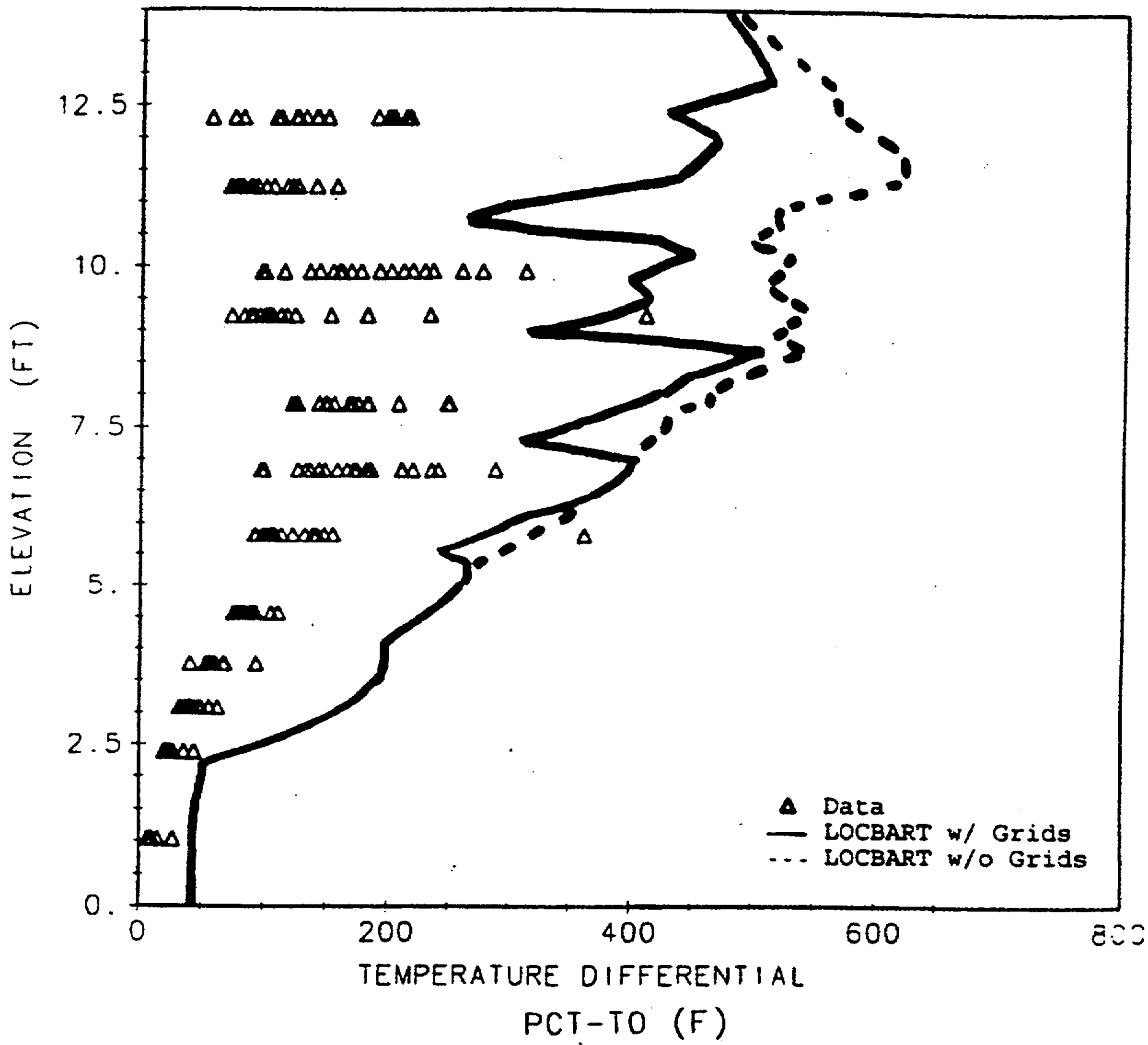


Figure 102. Maximum Clad Temperature Rise (PCT-TO) Versus Elevation for G2 562.

FIGURE 2

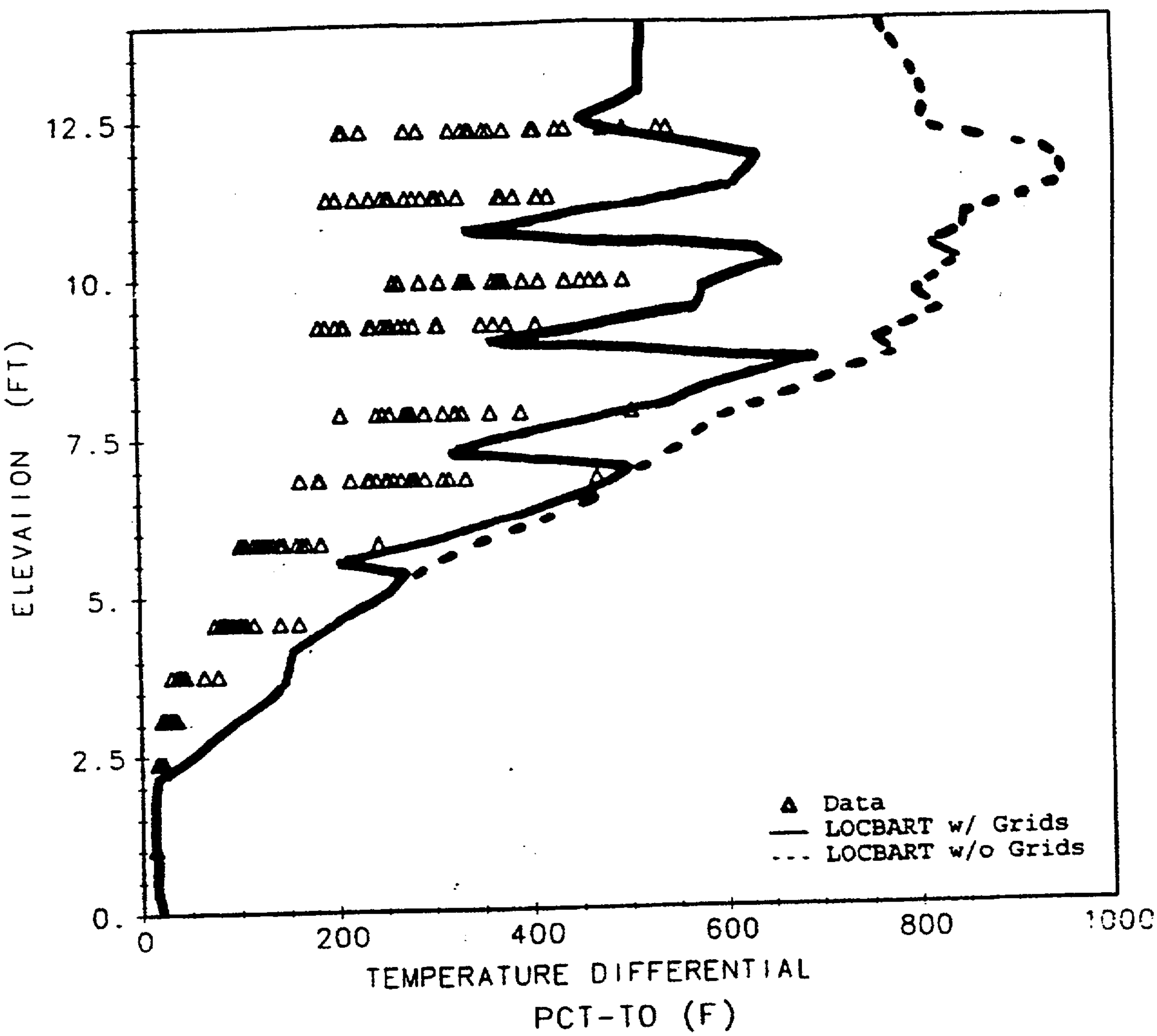


Figure 111. Maximum Clad Temperature Rise (PCT-TO) Versus Elevation for G2 564.

FIGURE 3

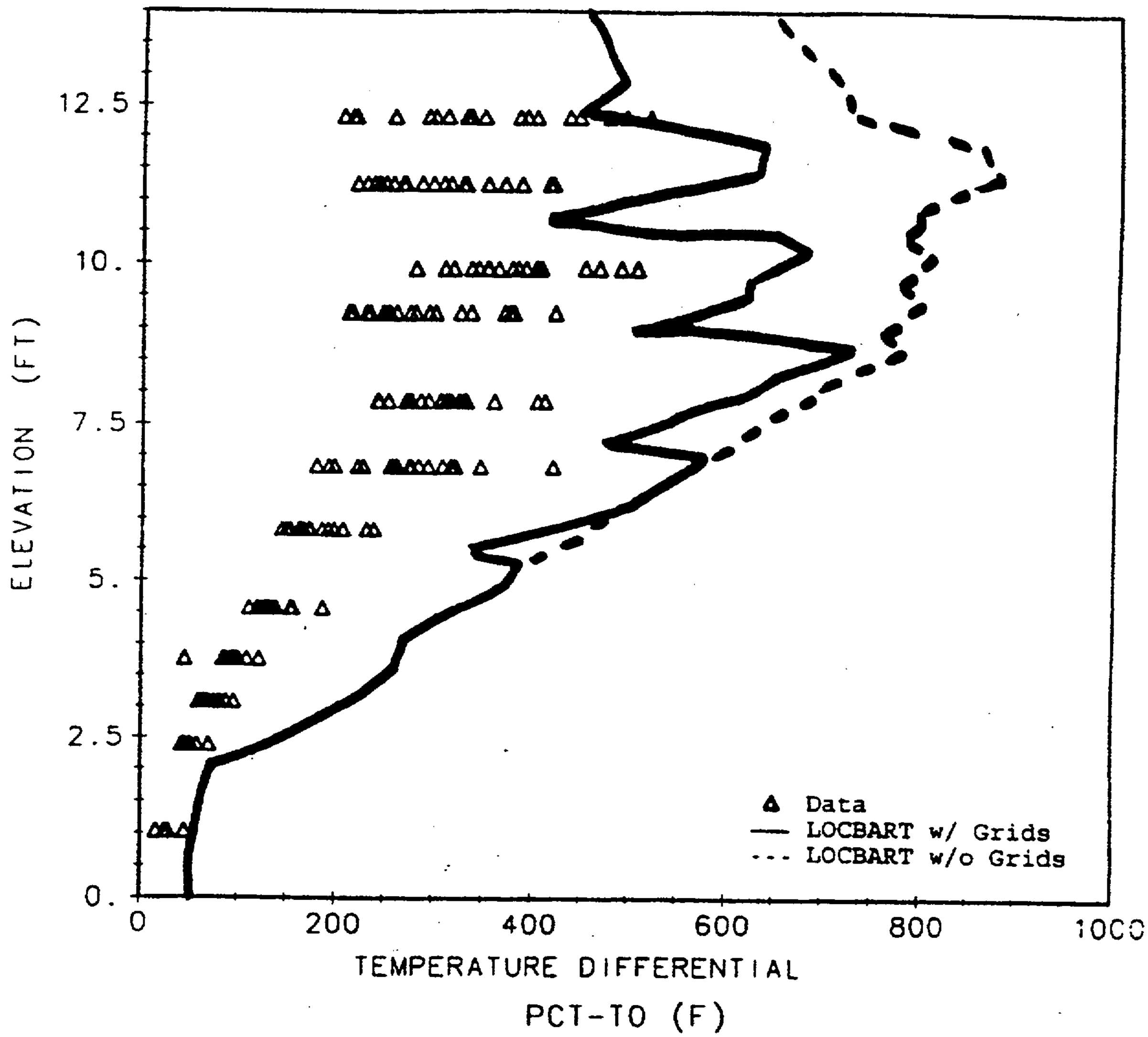


Figure 120. Maximum Clad Temperature Rise (PCT-TO) Versus Elevation for G2 568.

FIGURE 4

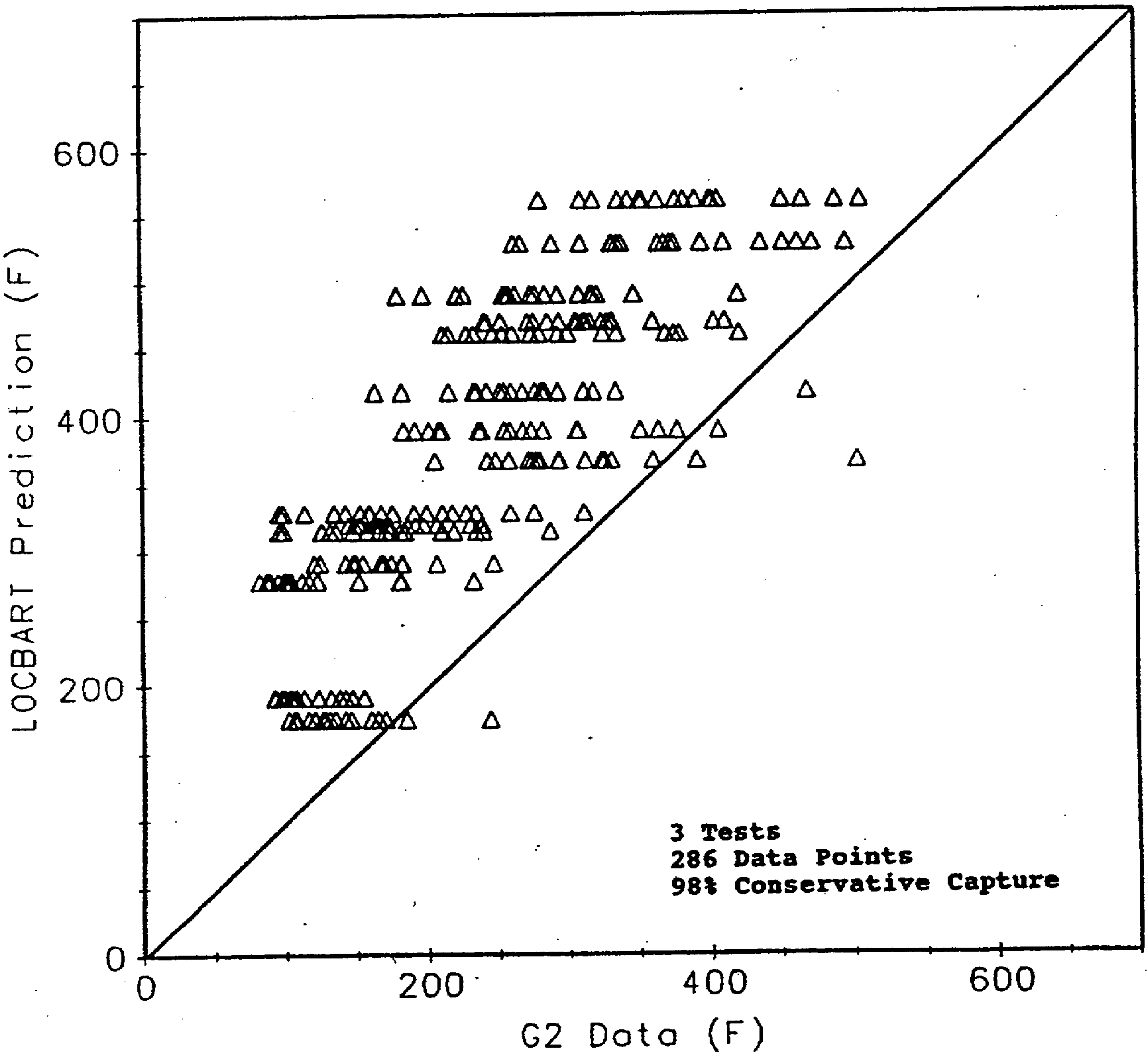


Figure 129. G2 Experiments Data Versus LOCBART Model Clad Temperature Rise Adjusted for [ ]a,c

3. COMPARISON OF BASH-EM AND BELOCA RESULTS

- BASH-EM CALCULATIONS HAVE BEEN COMPLETED FOR 2 PLANTS THAT ARE NOW LICENSED WITH BELOCA:
  - 3 LOOP, DRY CONTAINMENT (PLANT "A")
  - 4 LOOP, ICE CONDENSER (PLANT "B")
- USED STANDARD BASH-EM METHODOLOGY TO THE EXTENT POSSIBLE, WITH INPUTS SELECTED BASED ON BELOCA VALUES WHERE APPROPRIATE
- ALLOWS REASONABLY DIRECT COMPARISON OF BASH-EM PCT AND BELOCA 50^{TH} AND 95^{TH} PERCENTILE PCTs

PLANT "A" INITIAL / BOUNDARY CONDITIONS

Parameter	BASH-EM	BELOCA
General Information		
# Loops	3	
Fuel Array	17×17	
Containment Design	DRY	
Upper Head Temperature	T_{HOT}	
Core Power / Peaking Factors / SGTP		
Core Power w/Uncertainty (MWt)	2830.5	2830.5
F_Q	2.5	2.5
$F_{\Delta H}$	1.7	1.7
Maximum SGTP Level (%)	20	20
ECCS Information		
Single Failure Assumption	1 Train	1 Train
SI Delay Time w/LOOP (s)	27	27
Accumulator Pressure (psia)	600	600-680
Accumulator Water Volume (ft^3/acc)	965	965-995
Accumulator Water Temp. (°F)	120	90-120

PLANT "B" INITIAL / BOUNDARY CONDITIONS

Parameter	BASH-EM	BELOCA
General Information		
# Loops	4	
Fuel Array	17×17	
Containment Design	ICE	
Upper Head Temperature	T_{COLD}	
Core Power / Peaking Factors / SGTP		
Core Power w/Uncertainty (MWt)	3479.2	3479.2
F_Q	2.5	2.5
$F_{\Delta H}$	1.65	1.65
Maximum SGTP Level (%)	10	10
ECCS Information		
Single Failure Assumption	1 Train	1 Train
SI Delay Time w/LOOP (s)	32	32
Accumulator Pressure (psia)	600	600-705
Accumulator Water Volume (ft^3/acc)	1050	1005-1095
Accumulator Water Temp. (°F)	120	100-130

FIGURE 5

(a,c)

FIGURE 6

(a,c)

- [

]$^{(a,c)}$

4. TIMING OF DOWNCOMER (DC) BOILING

- WCOBRA/TRAC PREDICTS EARLIER ONSET OF DC BOILING THAN BASH-EM
  - BASH USES 2-VOLUME FLUID NODE MODEL IN DC (FIGURE 7; WCAP-10266-P-A REVISION 2)

- HOWEVER, THE FACTORS THAT CONTRIBUTE TO EARLIER DC BOILING IN BELOCA ALSO ENHANCE CORE HEAT TRANSFER, PROVIDING SUBSTANTIAL OFFSETTING MARGIN

  1. ADDITIONAL CONDENSATION DURING BLOWDOWN LEADS TO EARLIER END OF BYPASS, SHORTER REFILL
     - BENEFIT FOR REALISTIC CALCULATION (ESTIMATED 180°F IN NUREG/IA-0127)

  2. NO REQUIREMENT TO SUBTRACT WATER INJECTED PRIOR TO END OF BYPASS
     - BENEFIT FOR REALISTIC CALCULATION, THOUGH REMAINING WATER IS AT ELEVATED TEMPERATURE

  3. LOWER CORE STORED ENERGY AT BEGINNING OF REFLOOD LEADS TO REWET OF LARGE REGIONS OF THE CORE, AND CORE/DC LEVEL OSCILLATIONS
     - IMPROVES CORE HEAT TRANSFER, BUT MIXES SATURATED WATER FROM CORE WITH SUBCOOLED WATER IN LOWER PLENUM AND DC

FIGURE 7

i = intact cold leg node (homogeneous)
jm = lower downcomer node (volume pair)
jn = upper downcomer node (volume pair)
k = containment node (homogeneous)

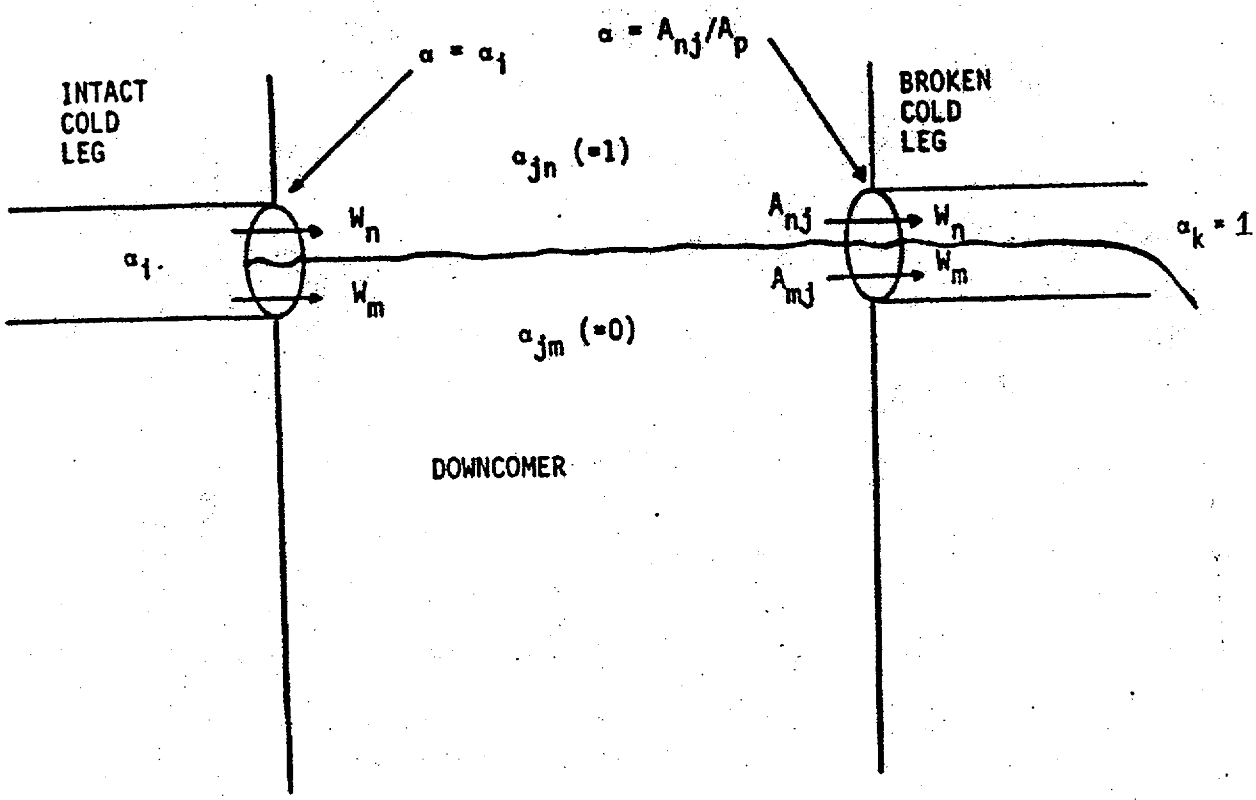


Figure 3-15. Flow Links Connecting Volume Pairs

- LOCBART CALCULATIONS FOR PLANTS "A" AND "B" [
  ][(a,c)]

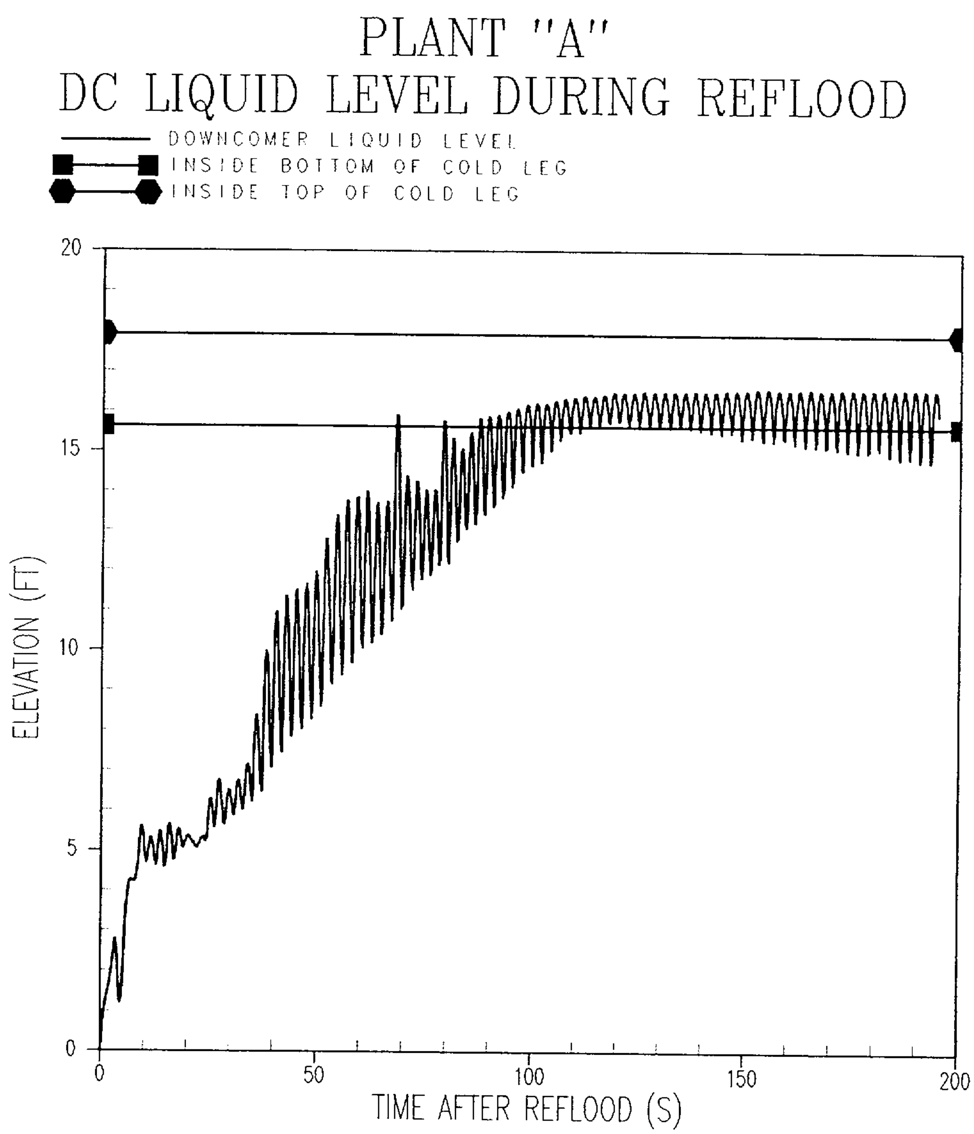
- FIGURE 8 SHOWS [
  ][(a,c)]
  FOR PLANT "A", DUE IN PART TO CONSERVATIVE MODELING AND APPENDIX K REQUIREMENTS

- FIGURE 9 SHOWS THE DC LIQUID LEVEL DURING REFLOOD FOR PLANT "A"; EXCESSIVE LOSS OF ACCUMULATOR WATER LEADS TO SEVERE DC UNDERFILL EARLY IN REFLOOD

FIGURE 8

(a,c)

FIGURE 9


PLANT "A"
DC LIQUID LEVEL DURING REFLOOD
DOWNCOMER LIQUID LEVEL
INSIDE BOTTOM OF COLD LEG
INSIDE TOP OF COLD LEG
ELEVATION (FT)
0
5
10
15
20
0
50
100
150
200
TIME AFTER REFLOOD (S)

- SENSITIVITY OF BASH TO KEY PARAMETERS

  - INCREASING CONTAINMENT PRESSURE DELAYS DC BOILING (FIGURE 10)

  - DECREASING INITIAL ACCUMULATOR WATER TEMPERATURE DELAYS DC BOILING (FIGURE 11)

  - INCREASING PUMPED INJECTION FLOW AFTER ACCUMULATOR EMPTY TIME DELAYS DC BOILING (FIGURE 12)

    * NO DC BOILING PREDICTED TO OCCUR FOR INCREASES OF 80% AND 100% (E.G., MAX SI)

FIGURE 10

(a,c)

FIGURE 11

(a,c)

FIGURE 12

(a,c)

CONCLUSIONS

- VALIDATION OF LOCBART SPACER GRID MODEL DEMONSTRATES CONSERVATISM IN CORE REFLOOD HEAT TRANSFER PREDICTIONS

- [

  ]$^{(a,c)}$

- FACTORS THAT LEAD TO EARLIER DC BOILING IN WCOBRA/TRAC ALSO ENHANCE CORE COOLING, PROVIDING SIGNIFICANT OFFSETTING MARGIN

- BASED ON THE PRECEDING INFORMATION, BASH-EM UPDATES TO EXPLICITLY MODEL DC BOILING ARE NOT WARRANTED