GENERAL ELECTRIC

NUCLEAR POWER

SYSTEMS DIVISION

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MFN 133-80

August 5, 1980

THIS DOCUMENT CONTAINS POOR QUALITY PAGES

U.S. Nuclear Regulatory Commission
Division of Systems Integration
Office of Nuclear Reactor Regulation
Washington, D.C. 20555

Attention: Paul S. Check
Assistant Director for Plant Systems

Gentlemen:

SUBJECT: SUMMARY OF AUGUST 5, 1980 NRC/GE MEETING ON CORE SPRAY DESIGN METHODOLOGY

References:
1. Letter from R.H. Buchholz to D.G. Eisenhut, dated April 21, 1980, subject "Responses to NRC Questions on Core Spray Design Methodology Confirmation Test"
2. NRC internal memo from L.B. Marsh to P.S. Check, dated February 1, 1980, subject "Summary of Meeting with General Electric Company Regarding Steam Effects on BWR Core Spray Distribution"

This letter summarizes the August 5, 1980 NRC/GE meeting held to resolve the remaining issues related to the General Electric core spray design methodology.

The purpose of the August 5 meeting was to address Wayne Hodges' informal questions about the responses to the formal questions provided by Reference 1. The formal questions were identified during a November 15, 1979 NRC/GE meeting. The November 15, 1979 meeting is summarized by Reference 2.

During the August 5 meeting, General Electric resolved all the remaining methodology issues to the satisfaction of the NRC staff present. The charts used during the meeting are included as an attachment to this letter. The attachment contains our characterization of the remaining issues along with our detailed response.

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Now that we have resolved all the remaining methodology issues, we look forward to your early concurrence and closure of the core spray design methodology development through issuance of the NRC acceptance letter, as defined in Reference 2. We consider August 15, 1980 as an appropriate target date for the closure of this phase.

If you need any additional information, please contact Luis F. Rodriguez of my staff at 408-925-2460.

Very truly yours,

W.H. D'Ardenne

W. H. D'Ardenne, Manager
Safety Evaluation Programs
Safety & Licensing Operation

Attachment

cc: Wayne Hodges (NRCO
L.S. Gifford (GE, Bethesda)

BWR CORE SPRAY DESIGN

METHODOLOGY MEETING

—

PRESENTATION TO NRC

—

AUGUST 5, 1980

BWR CORE SPRAY DESIGN METHODOLOGY

NRC/GE MEETING
AUGUST 5, 1980
AGENDA

•	INTRODUCTION	LF RODRIGUEZ
•	PROGRAM OVERVIEW	JA ALAI
•	REMAINING METHODOLOGY ISSUES DISCUSSION	SA SANDOZ

- STEAM FLOW EFFECTS
- UNCERTAINTY BANDS
- DOUBLE HEADER SUPERPOSITION
  - SINGLE vs DOUBLE HEADER DATA
  - APPLICATION TO OTHER BWR DESIGN

•	CONCLUSION	LF RODRIGUEZ
•	OPEN DISCUSSION	ALL

LFR
8/5/80

BWR CORE SPRAY METHODOLOGY

PURPOSE OF MEETING

- RESOLVE REMAINING BWR CORE SPRAY METHODOLOGY ISSUES

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8/5/80

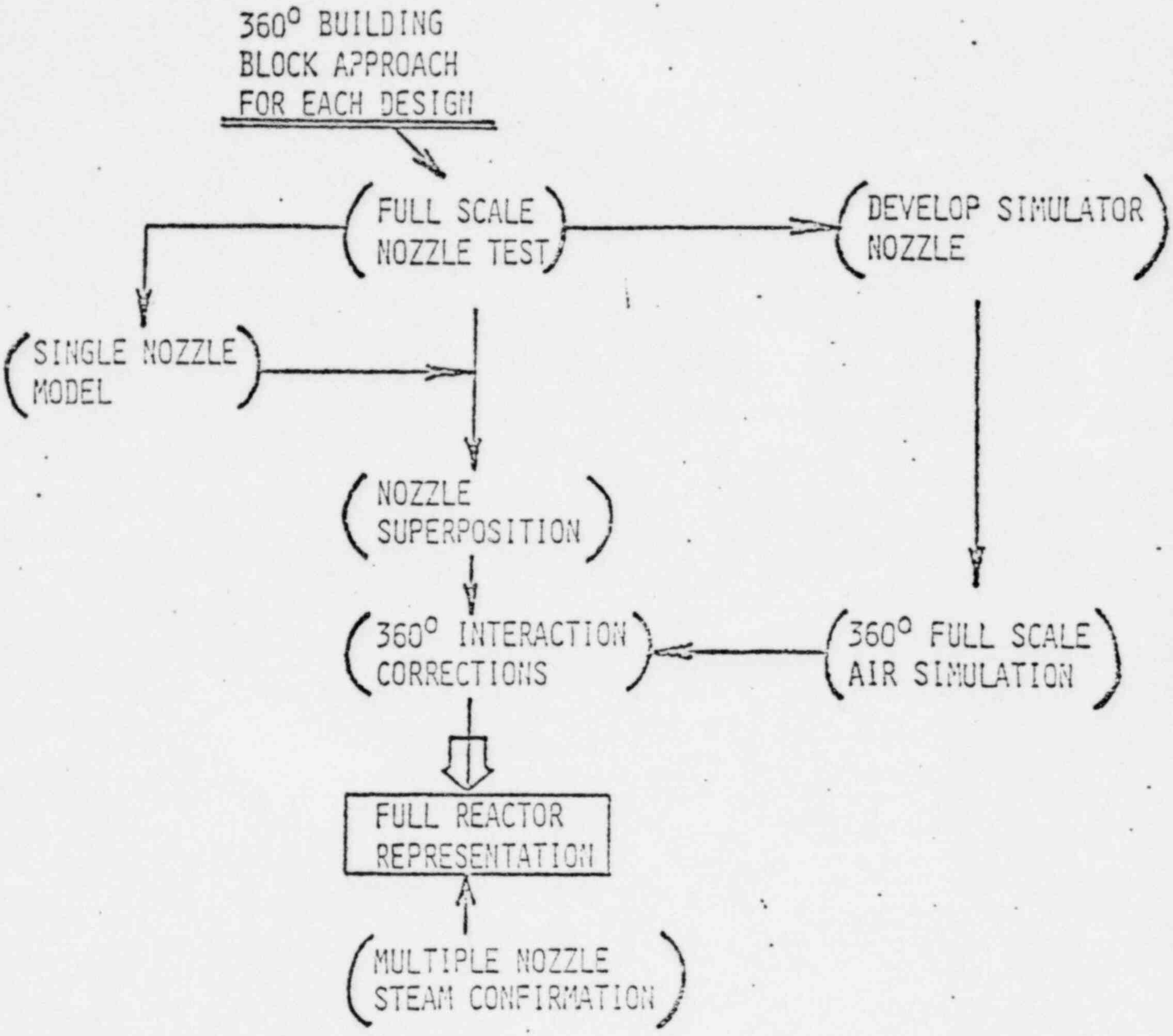
PROGRAM OVERVIEW

- BACKGROUND
- METHODOLOGY DESCRIPTION
  - -- BLOCK DIAGRAM
  - -- INTERIM SER
  - -- TAP A-16, REVISION 1
  - -- LYNN CONFIRMATION TESTS

BACKGROUND

• NEDO-20566-3	APRIL 1977
• GE PRESENTATION TO NRC	DECEMBER 1977
• GE PRESENTATION TO NRC	JANUARY 1978
• INTERIM SER	JUNE 1978
• FINAL LYNN CONFIRMATION TEST REPORT	AUGUST 1979
• GE PRESENTATION TO NRC	NOVEMBER 1979
• GE LETTER - RESPONSES TO NRC QUESTIONS ON METHODOLOGY CONFIRMATION TESTS	APRIL 1980

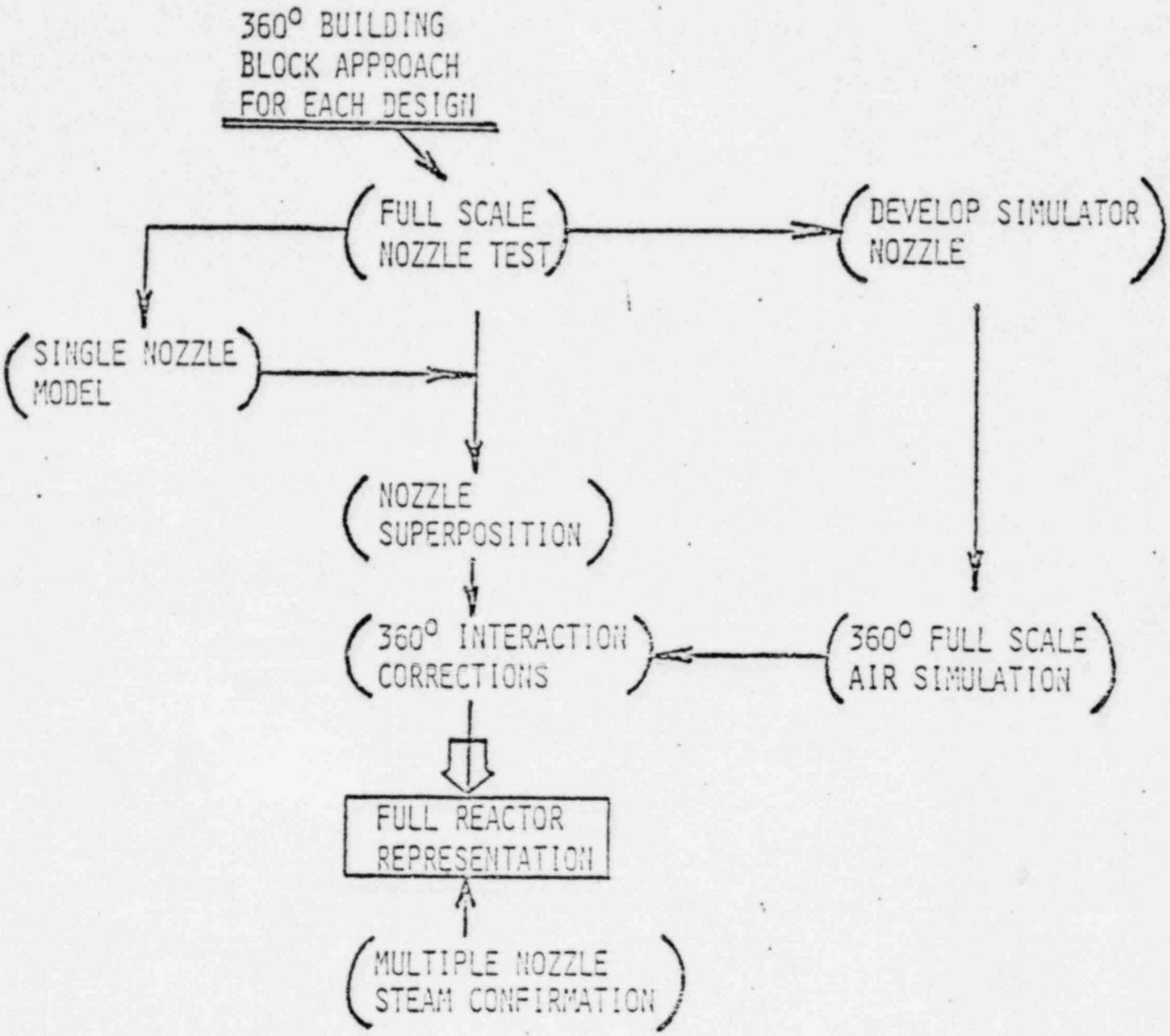
CORE SPRAY PROGRAM

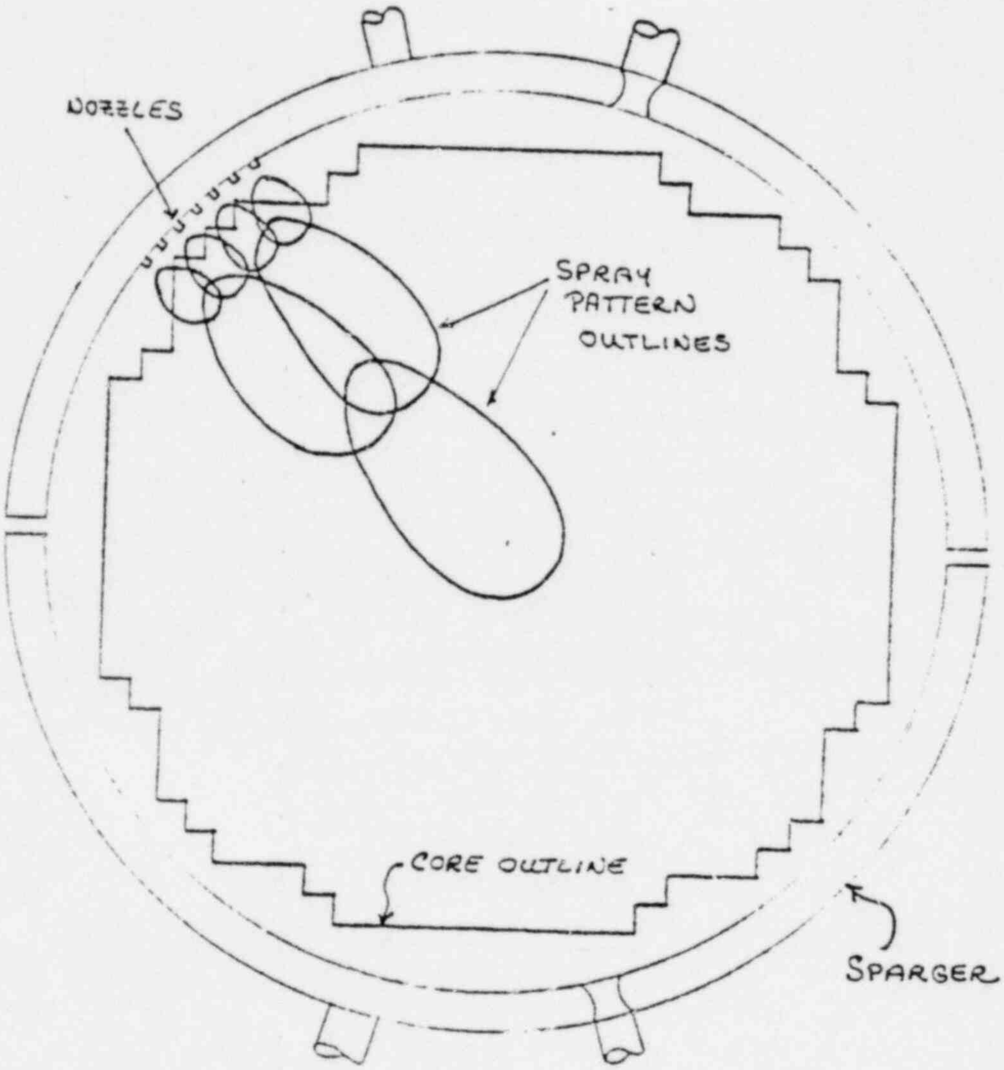


REMAINING METHODOLOGY
ISSUES DISCUSSION

- REVIEW
- STEAM FLOW EFFECTS
- UNCERTAINTY BANDS
- DOUBLE HEADER SUPERPOSITION
  - SINGLE VS. DOUBLE HEADER DATA
  - APPLICATION TO OTHER BWR DESIGNS WITH CLOSE VERTICAL-SPACED DOUBLE HEADERS

CORE SPRAY PROGRAM

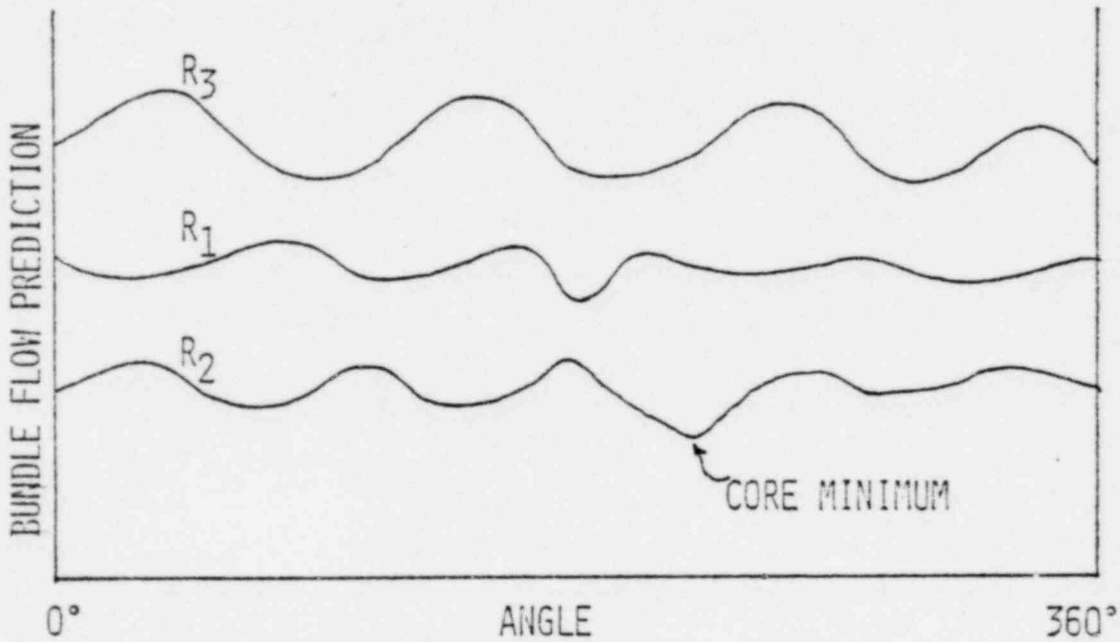




Superposition of Individual Nozzle Spray Patterns

CALCULATION SEARCHES

FOR CORE MINIMUM

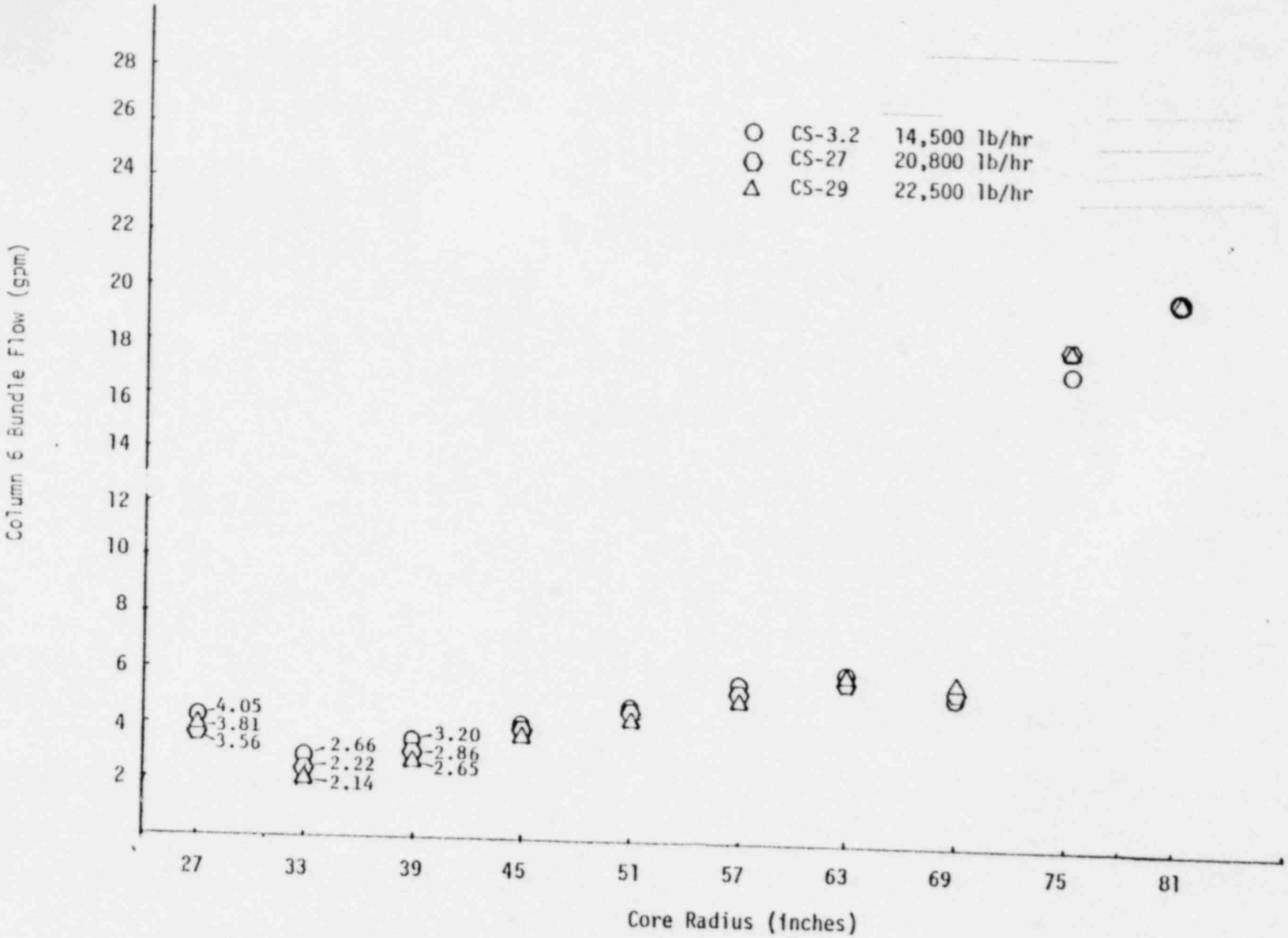


QUESTION

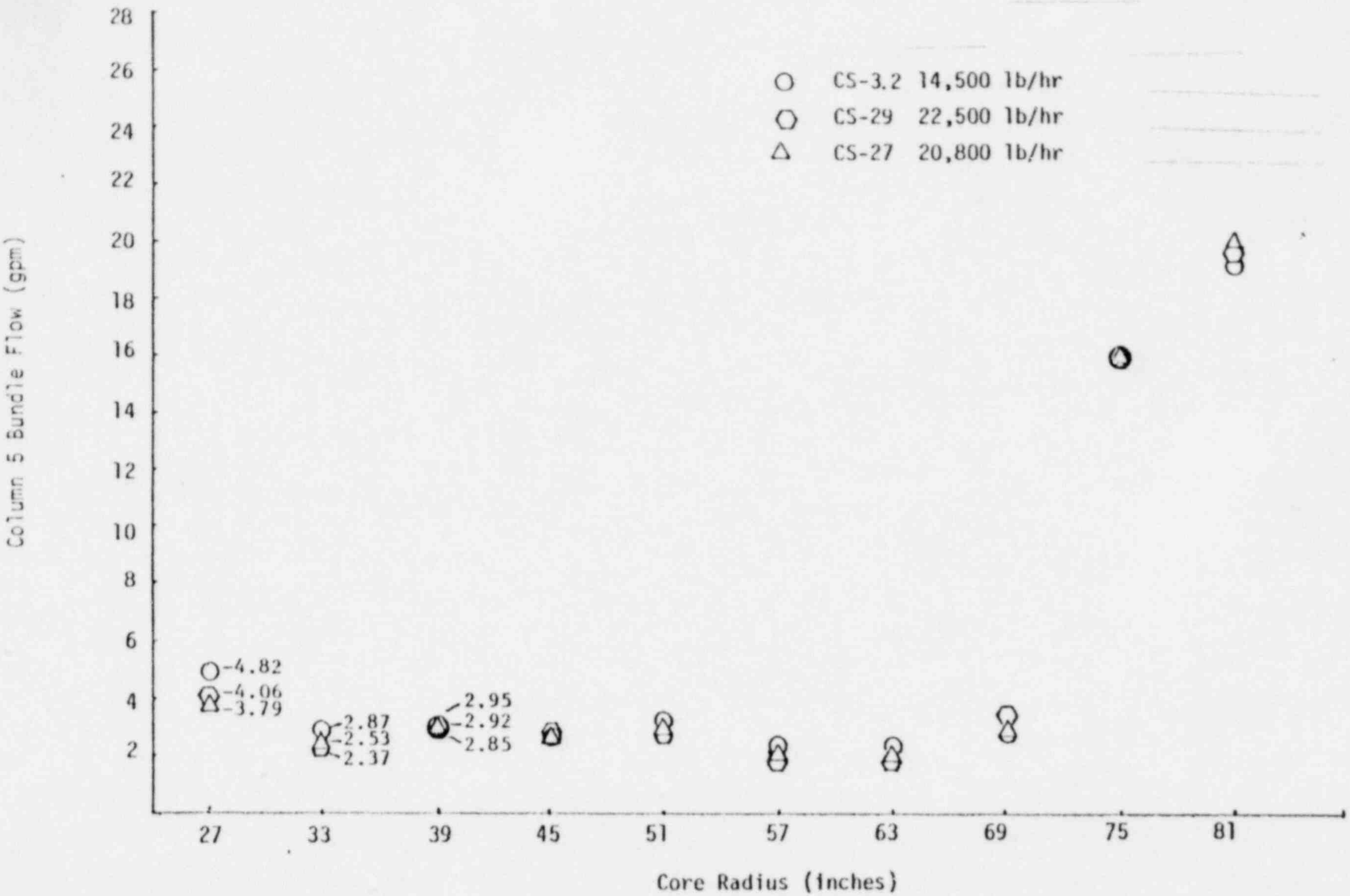
FIGURE 6A3 OF APRIL, 1980 SUBMITTAL SHOWS AN APPARENT SYSTEMATIC EFFECT OF STEAM UPDRAFT ON SPRAY FLOWS

ANSWER

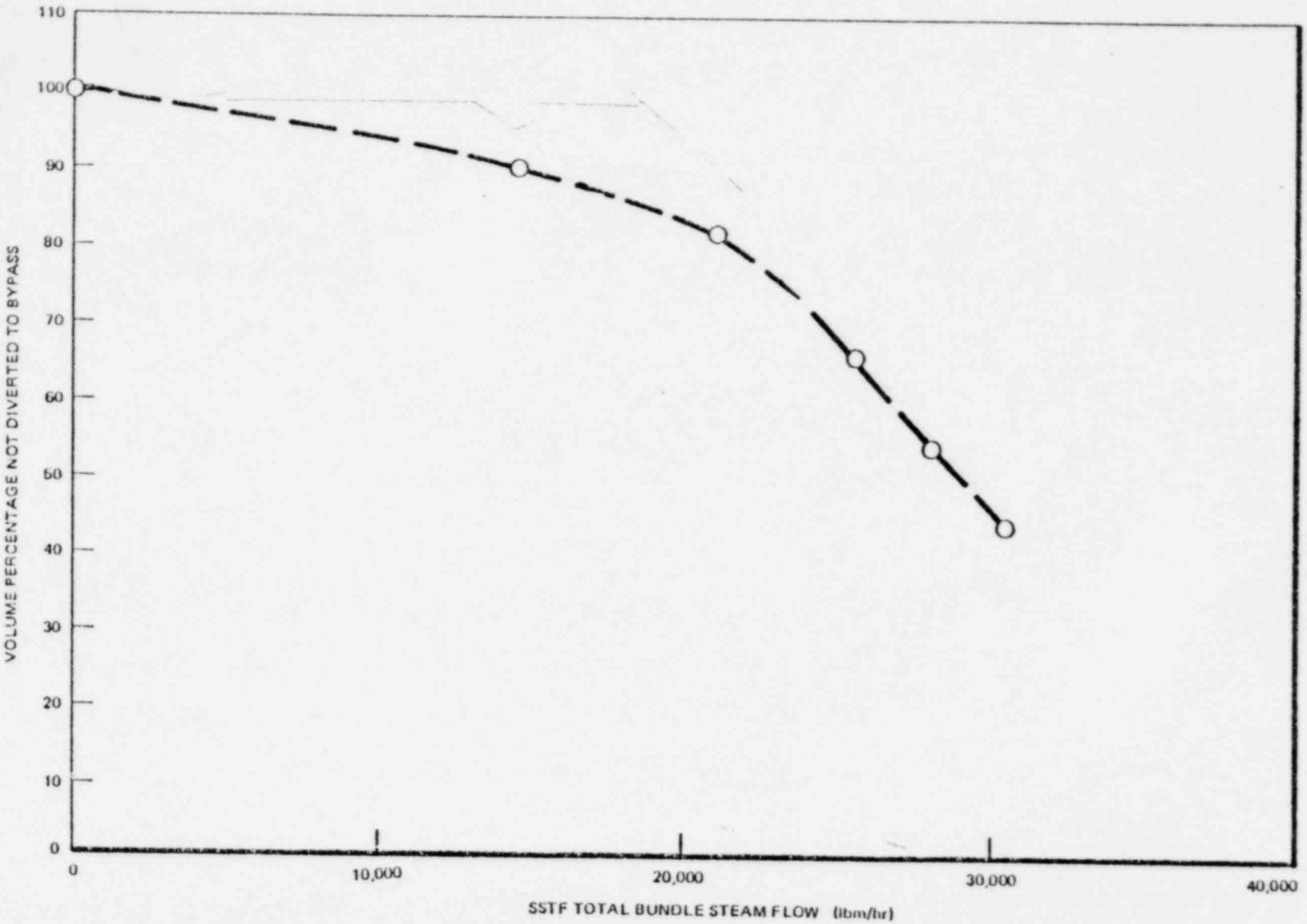
THERE ARE TWO EFFECTS OF STEAM FLOW ON THE SPRAY DROPLETS. ONE IS A FIELD EFFECT WHERE THE STEAM FLOW TENDS TO CHANGE THE DROPLET LANDING POINT THROUGH DRAG EFFECTS ACTING ALL ALONG THE TRAJECTORY. THE OTHER EFFECT IS LOCAL DIVERSION OF THE DROPLETS BY RELATIVELY HIGHER VELOCITY STEAM JETS IMMEDIATELY ABOVE THE FUEL BUNDLES. THE MINOR STEAM FLOW EFFECT OBSERVED IN FIGURE 6A3 IS CAUSED BY THE LOCAL DROP DIVERSION PHENOMENON. HOWEVER, EVEN FOR THE LYNN FACILITY THAT MAXIMIZES THIS EFFECT BY HAVING NO STEAM FLOW IN THE BYPASS (REACTOR BYPASS STEAM FLOW TENDS TO DIVERT THE DROPLETS BACK TO THE FUEL BUNDLES), THE EFFECT IS STILL SMALL (AVERAGE EFFECT 14% OVER STEAM FLOW RANGE OF CONCERN).



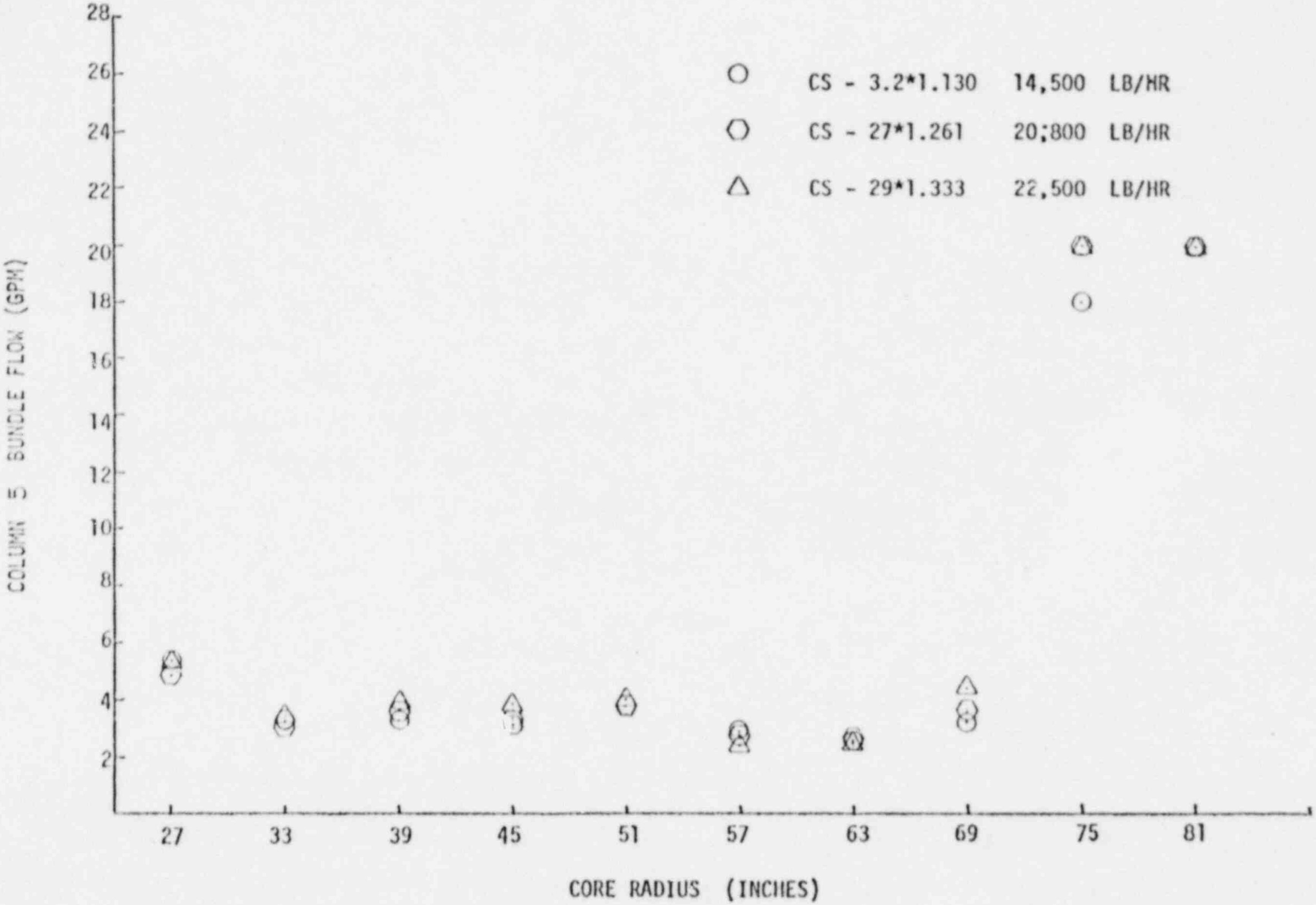
STEAM UPDRAFT EFFECT ON BUNDLE FLOW FOR HPCS



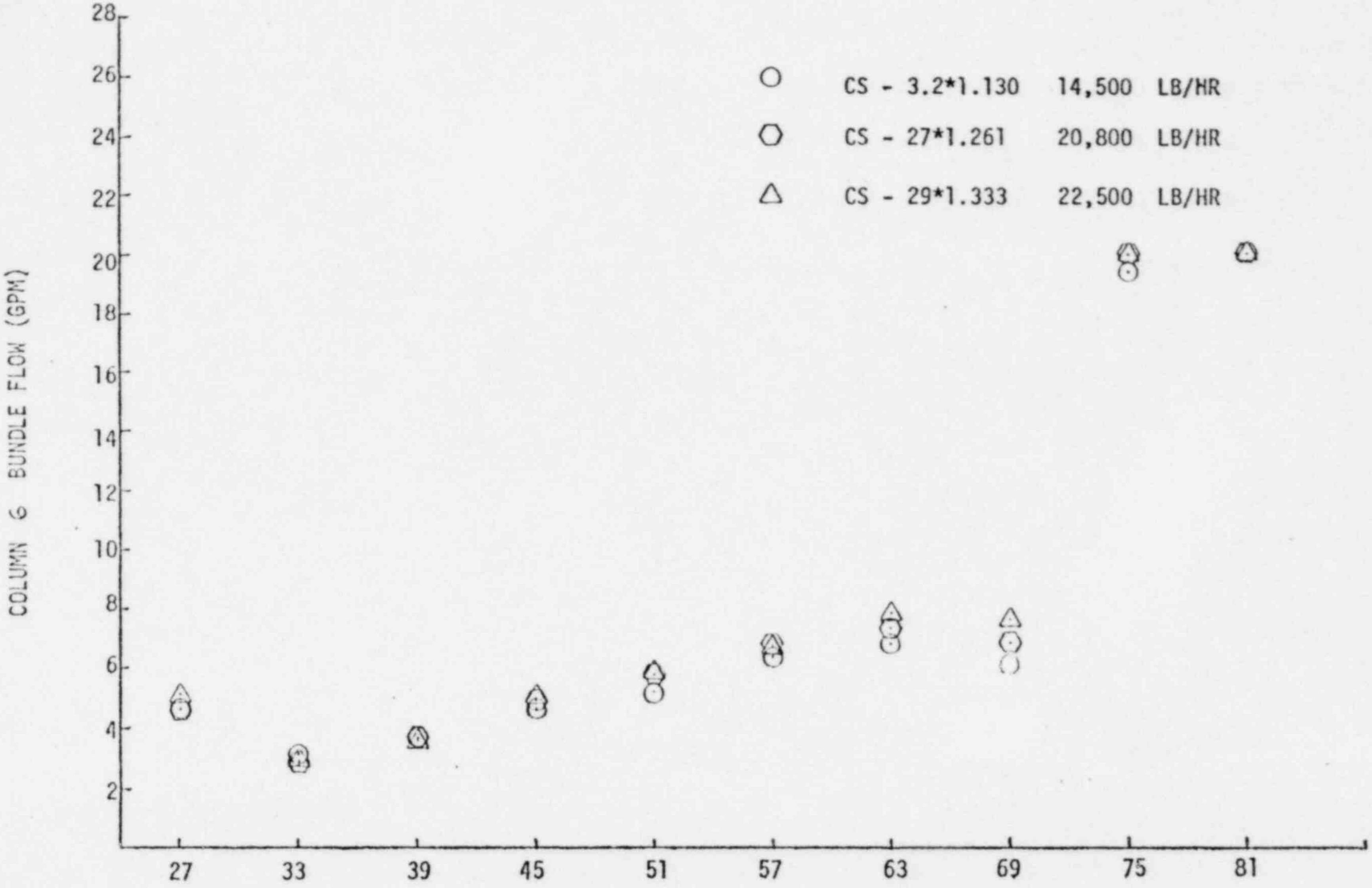
STEAM UPDRAFT EFFECT ON BUNDLE FLOW FOR HPCS



Calibration of Drop Diversion with no steam updraft in bypass



STEAM UPDRAFT EFFECT ON SPRAY DISTRIBUTION FOR HPCS - DATA ADJUSTED FOR DROP DIVERSION



STEAM UPDRAFT EFFECT ON SPRAY DISTRIBUTION FOR HPCS - DATA ADJUSTED FOR DROP DIVERSION

CONCLUSIONS

STEAM FLOW EFFECT IN DATA

- o MINOR STEAM FLOW TREND INDICATED
- o EFFECT CAUSED BY LOCAL DROPLET DIVERSION
  - NO UPDRAFT TREND IN ADJUSTED DATA
- o DROPLET DIVERSION MAXIMIZED BY LYNN FACILITY
  - NO STEAM UPDRAFT IN BYPASS
- o SMALL EFFECT EVEN FOR THIS FACILITY

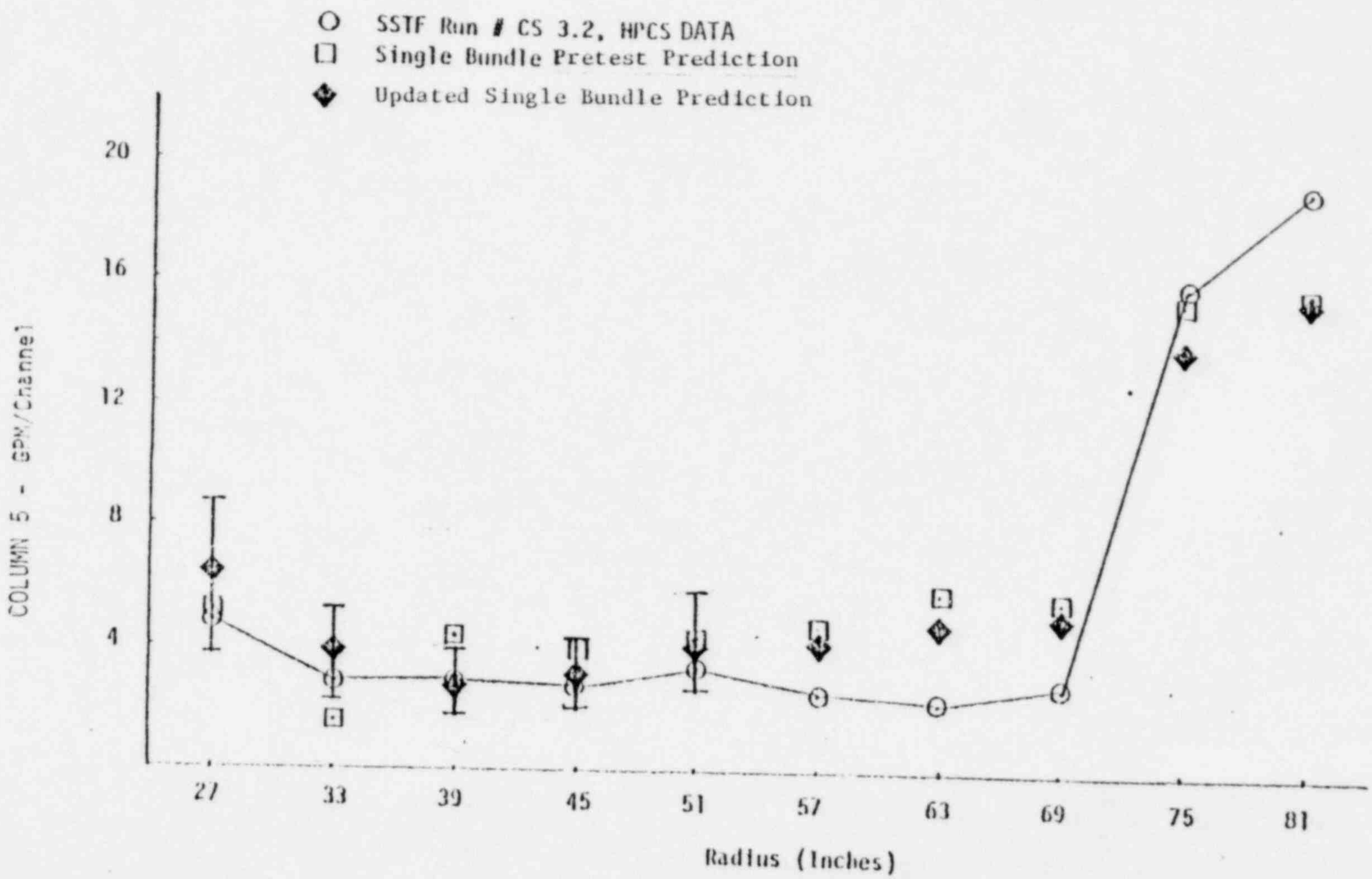
QUESTION

LYNN PRETEST PREDICTION UNCERTAINTY BANDS SEEM TO BE TOO LARGE. THEY SHOULD BE REDUCED BASED ON EXPERIENCE GAINED SINCE PRETEST PREDICTIONS WERE MADE.

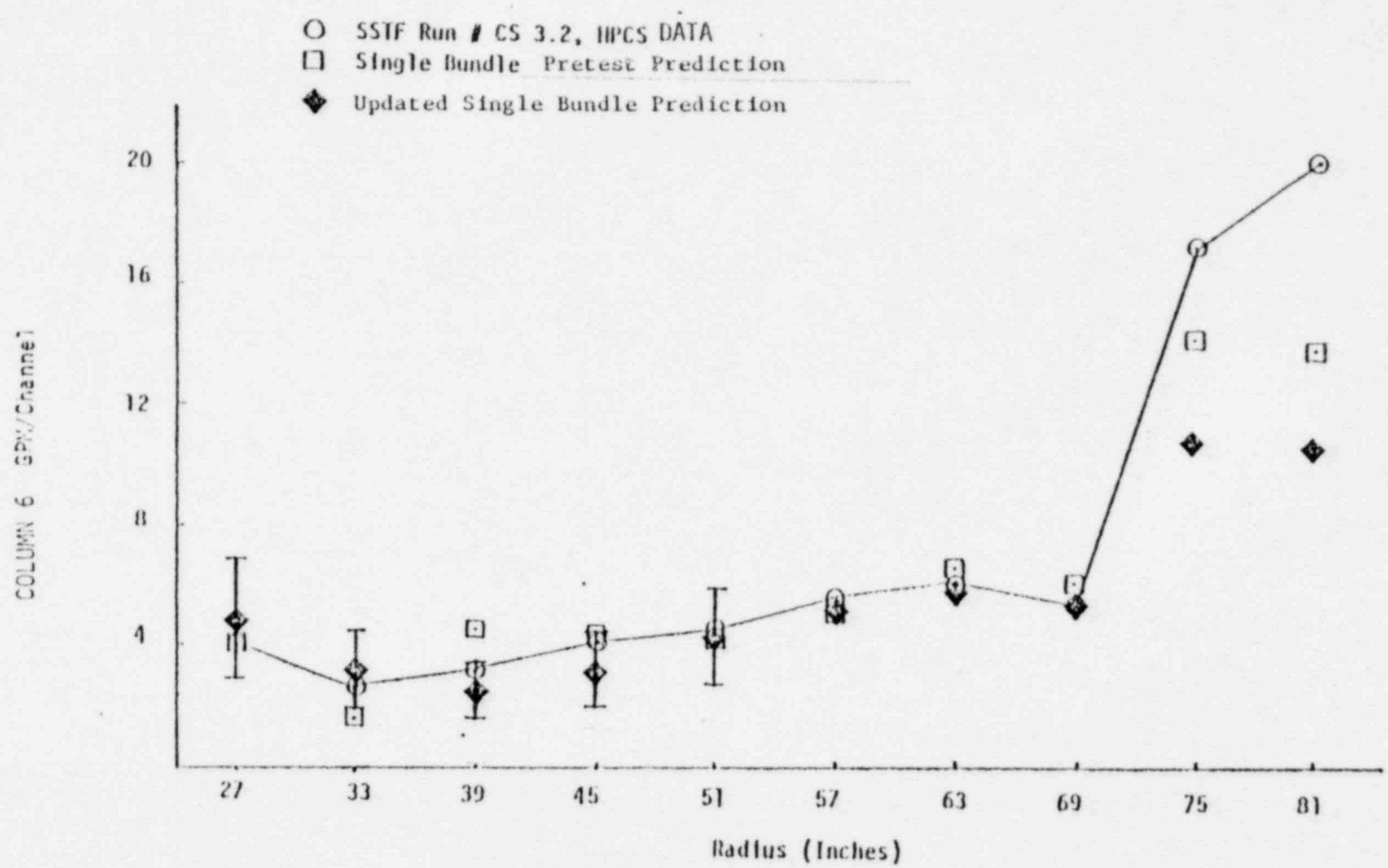
ANSWER

THE COLLECTION OF A LARGE SINGLE NOZZLE STEAM DISTRIBUTION DATA BASE SINCE THE PRETEST PREDICTIONS WERE PERFORMED (ASSOCIATED WITH THE BWR/6 SYSTEM DESIGN), NOW ALLOWS FOR SIGNIFICANTLY IMPROVED PREDICTIONS AND MUCH SMALLER UNCERTAINTY BANDS.

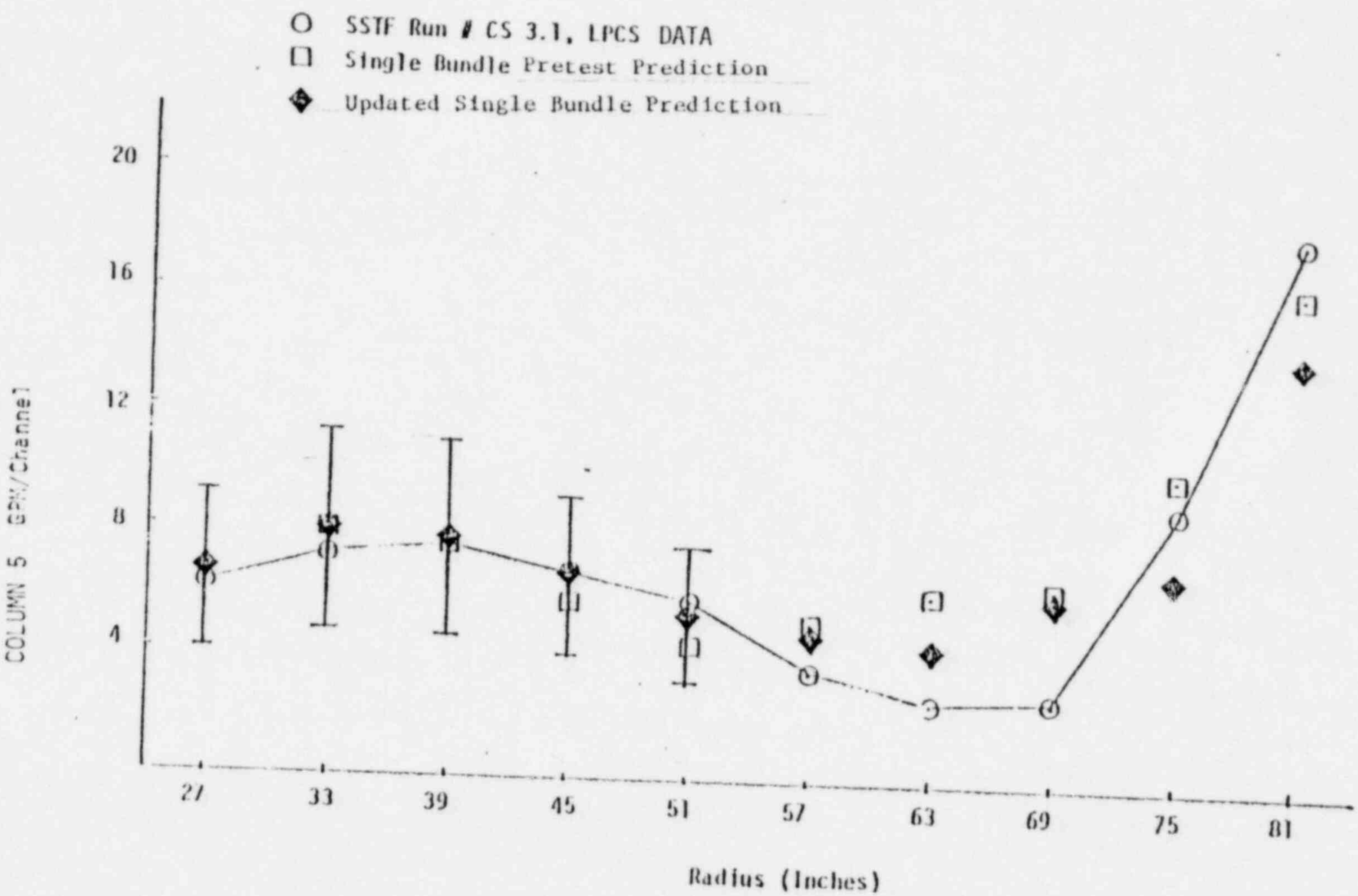
BWR/6 DESIGN METHOD PREDICTIONS OF SSTF



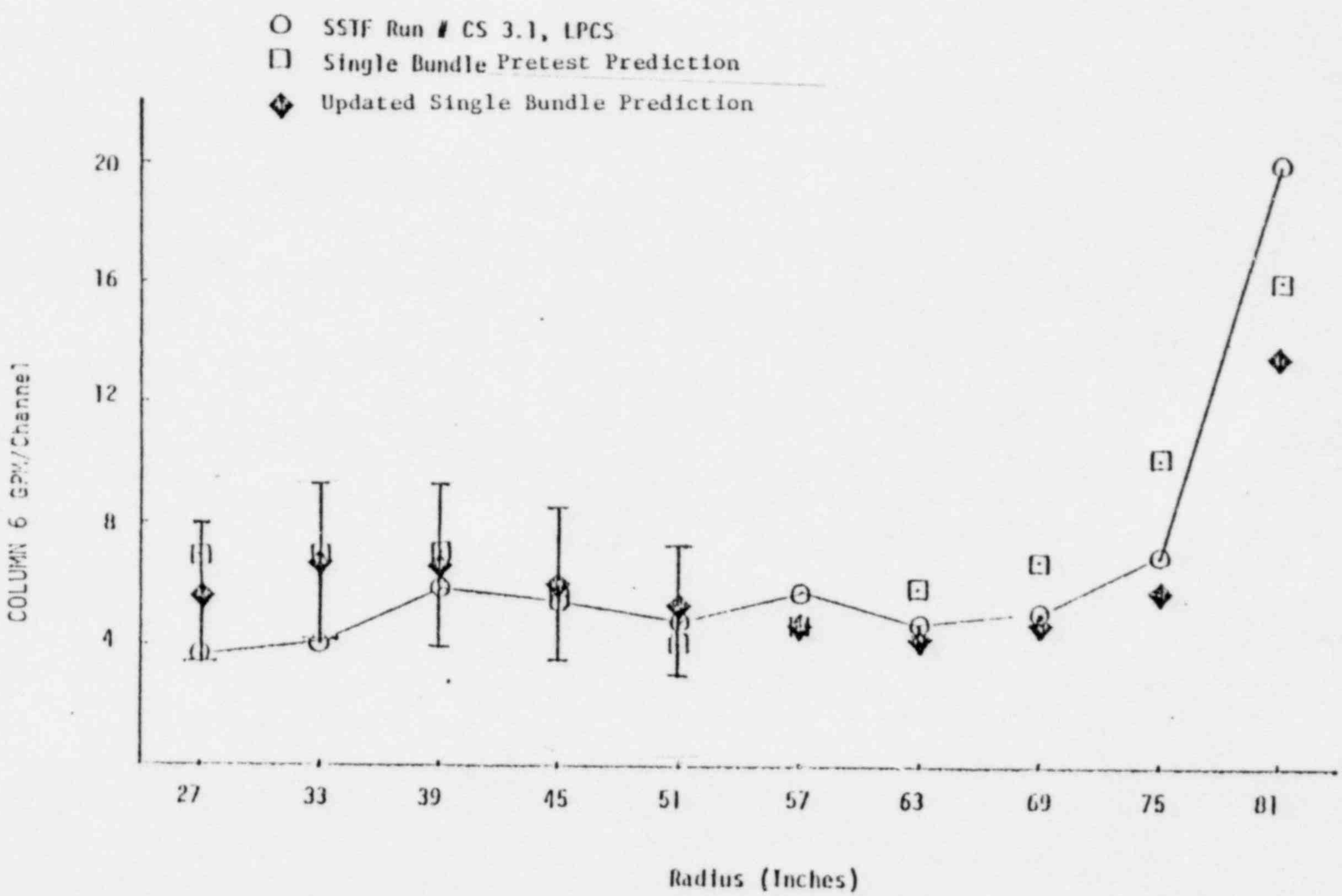
BWR/6 DESIGN METHOD PREDICTIONS OF SSTF



BWR/6 DESIGN METHOD PREDICTIONS OF SSTF



BWR/6 DESIGN METHOD PREDICTIONS OF SSTF



CONCLUSIONS

DATA UNCERTAINTY BANDS

- o BWR/6 DESIGN DATA BASE REDUCES UNCERTAINTIES
  - EXTENDED SINGLE NOZZLE STEAM DATA BASE

- o BWR/6 DESIGN VALUES IMPROVE SSTF PREDICTIONS
  - SINGLE NOZZLE MODEL "BEST-FITS" DATA BASE

QUESTION

SINCE THE DOUBLE HEADER INDIVIDUAL BUNDLE FLOWS ARE NOT THE SUPERPOSITION OF SINGLE HEADER FLOWS, DOES THIS MEAN THAT THE LOWEST FLOW FOR DOUBLE HEADER WILL NOT BE THE SUM OF THE LOWEST FLOWS FOR SINGLE HEADERS?

ANSWER

DOUBLE HEADER INTERACTION EFFECTS CAUSE SOME BUNDLES TO RECEIVE MORE FLOW THAN SUPERPOSITION OF SINGLE HEADER FLOWS, AND SOME BUNDLES LESS. THIS IS SEEN IN BOTH STEAM AND AIR DATA. HOWEVER DATA FOR BOTH STEAM TESTS AND AIR SIMULATOR TESTS SHOW LOWEST BUNDLE FLOW FOR THE DOUBLE HEADER IS APPROXIMATELY EQUIVALENT TO THE SUM OF LOWEST BUNDLE FLOWS FOR SINGLE HEADERS.

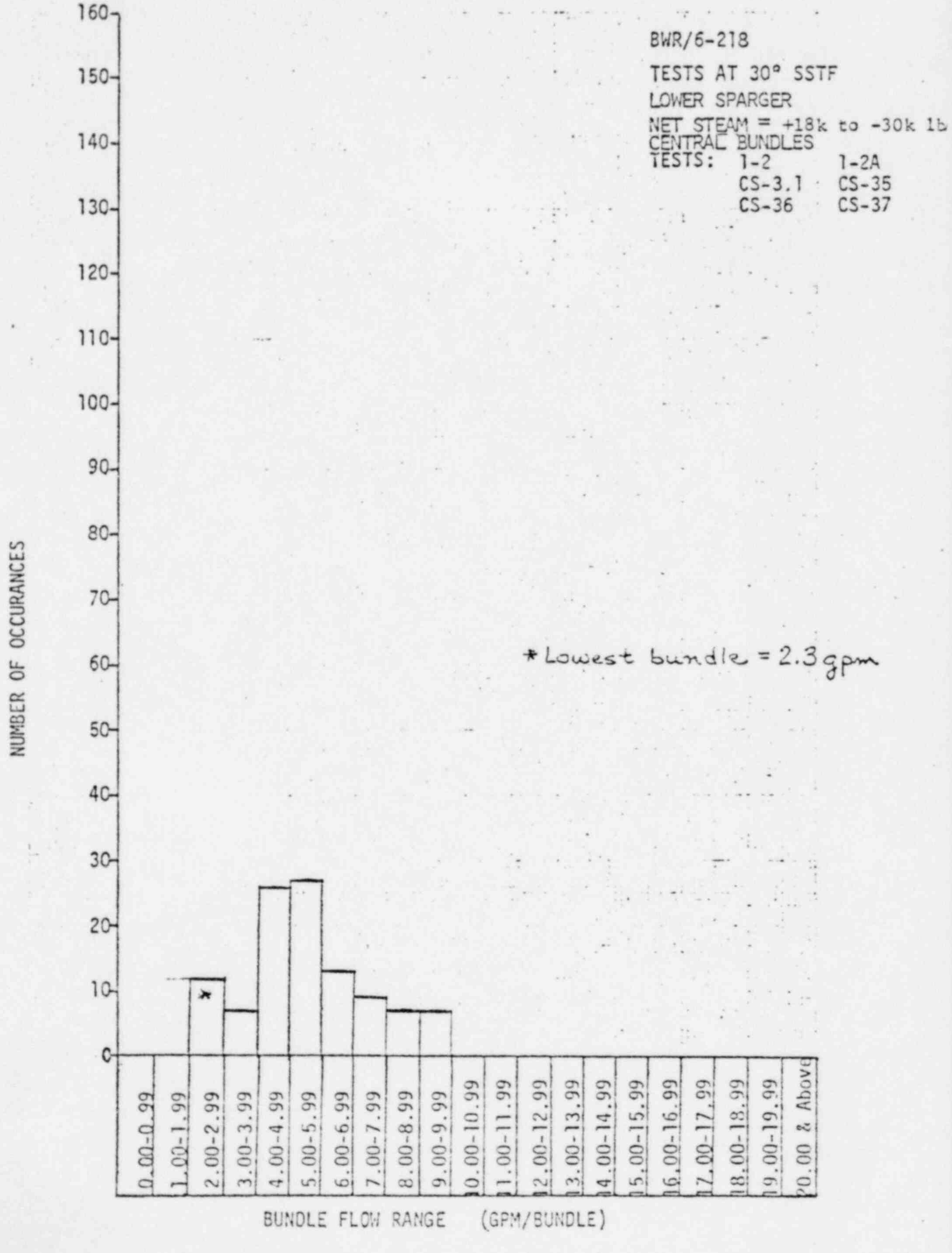
SAMPLE OF OBSERVED DEVIATIONS

FROM SUPERPOSITION IN

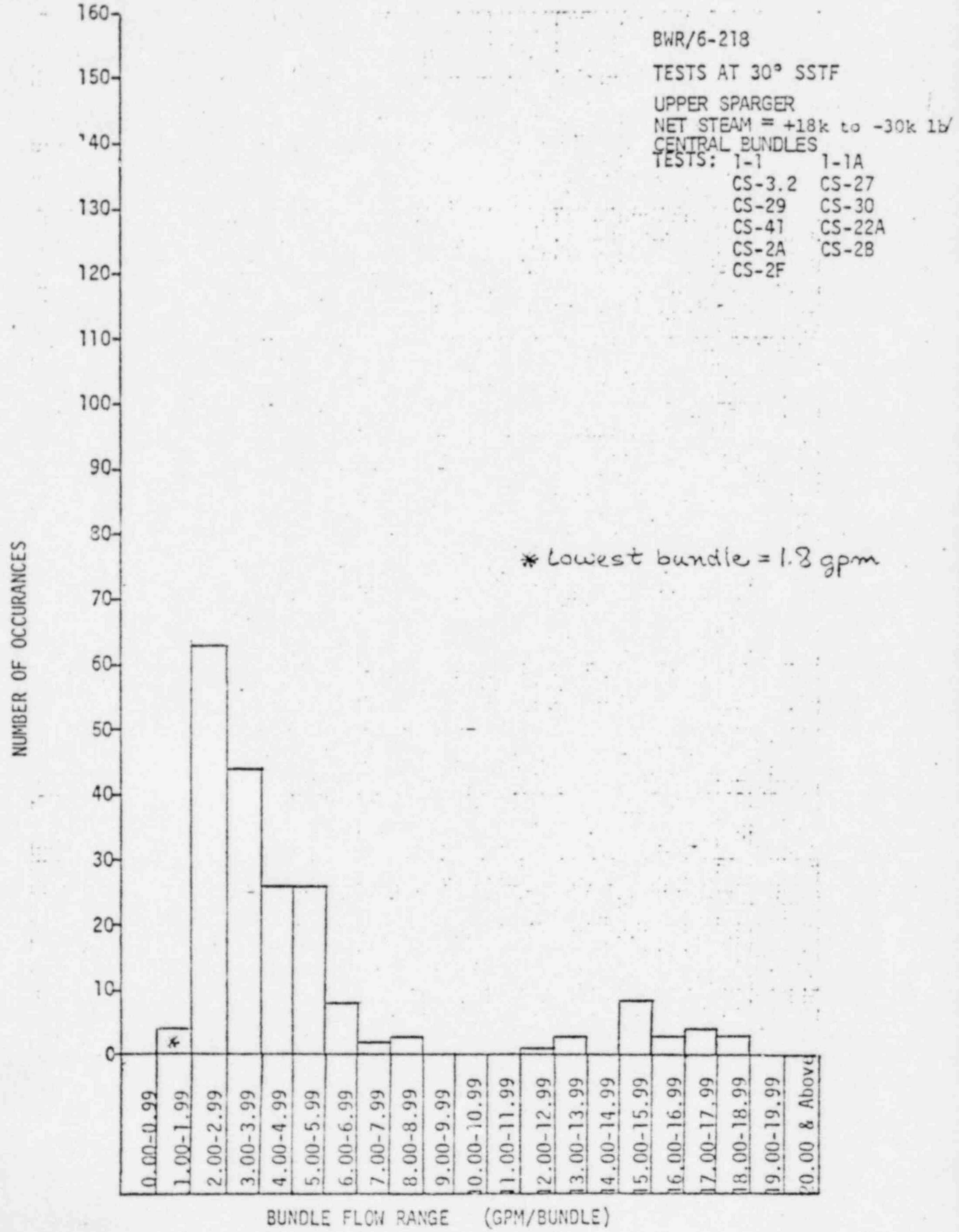
DOUBLE HEADER AIR TEST

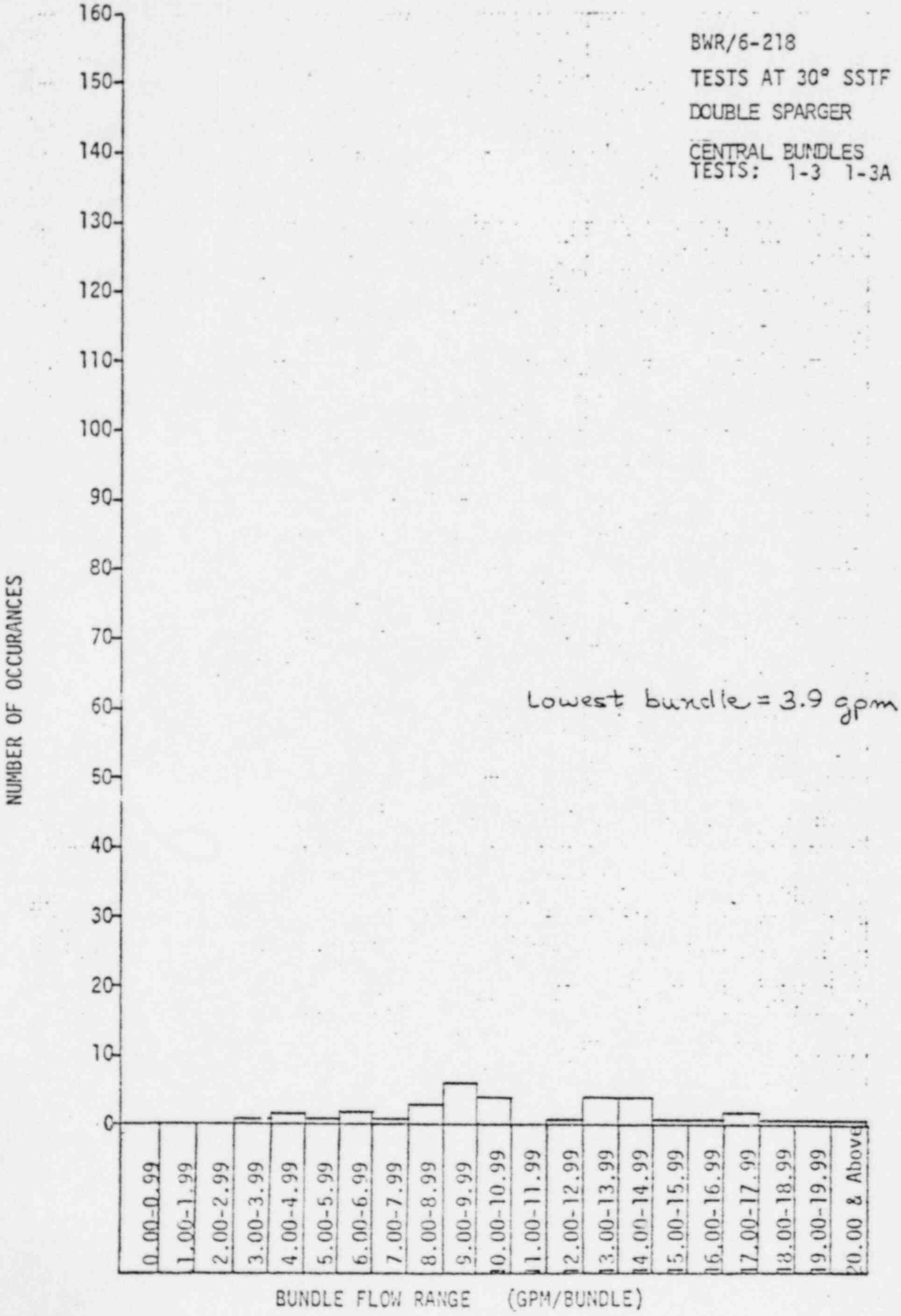
BWR/6-218

BUNDLE LOCATION	HPCS	LPCS	HPCS+LPCS
(17,17)	17.3GPM	9.5	15.7GPM
(17,18)	20.1	9.0	18.5
(15,19)	18.3	8.3	17.2
(13,19)	8.4	5.2	8.3
(24, 5)	4.8	3.5	4.1



BWR/6-218
TESTS AT 30° SSTF
LOWER SPARGER
NET STEAM = +18k to -30k lb
CENTRAL BUNDLES
TESTS: 1-2 1-2A
CS-3.1 CS-35
CS-36 CS-37
* Lowest bundle = 2.3 gpm
NUMBER OF OCCURANCES
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.00-0.99
1.00-1.99
2.00-2.99
3.00-3.99
4.00-4.99
5.00-5.99
6.00-6.99
7.00-7.99
8.00-8.99
9.00-9.99
10.00-10.99
11.00-11.99
12.00-12.99
13.00-13.99
14.00-14.99
15.00-15.99
16.00-16.99
17.00-17.99
18.00-18.99
19.00-19.99
20.00 & Above
BUNDLE FLOW RANGE (GPM/BUNDLE)

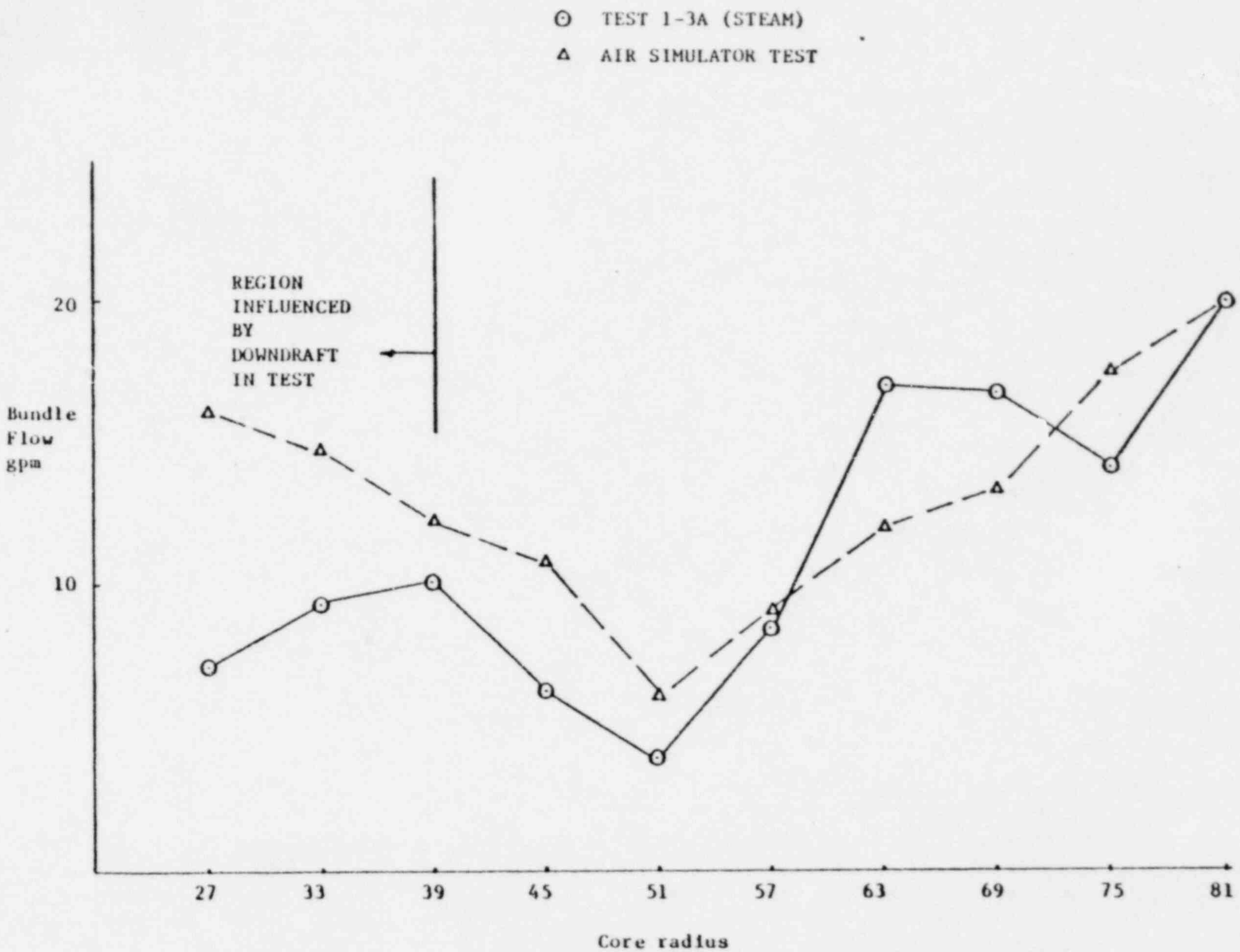

BWR/6-218
TESTS AT 30° SSTF
UPPER SPARGER
NET STEAM = +18k to -30k lb/
CENTRAL BUNDLES
TESTS: 1-1 1-1A
CS-3.2 CS-27
CS-29 CS-30
CS-41 CS-22A
CS-2A CS-2B
CS-2F
* Lowest bundle = 1.8 gpm
NUMBER OF OCCURANCES
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
*
0.00-0.99
1.00-1.99
2.00-2.99
3.00-3.99
4.00-4.99
5.00-5.99
6.00-6.99
7.00-7.99
8.00-8.99
9.00-9.99
10.00-10.99
11.00-11.99
12.00-12.99
13.00-13.99
14.00-14.99
15.00-15.99
16.00-16.99
17.00-17.99
18.00-18.99
19.00-19.99
20.00 & Above
BUNDLE FLOW RANGE (GPM/BUNDLE)


BWR/6-218
TESTS AT 30° SSTF
DOUBLE SPARGER
CENTRAL BUNDLES
TESTS: 1-3 1-3A
Lowest bundle = 3.9 gpm
NUMBER OF OCCURANCES
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.00-0.99
1.00-1.99
2.00-2.99
3.00-3.99
4.00-4.99
5.00-5.99
6.00-6.99
7.00-7.99
8.00-8.99
9.00-9.99
10.00-10.99
11.00-11.99
12.00-12.99
13.00-13.99
14.00-14.99
15.00-15.99
16.00-16.99
17.00-17.99
18.00-18.99
19.00-19.99
20.00 & Above
BUNDLE FLOW RANGE (GPM/BUNDLE)

COMPARISON OF LOWEST MEASURED FLOWS

IN SINGLE AND DOUBLE HEADER TESTS

	HPCS	LPCS	HPCS+LPCS
STEAM BWR/6-218	1.8 GPM	2.3GPM	3.9GPM
AIR SIMULATORS			
218	2.3	2.1	4.4
238	2.6	1.9	3.9
251	2.4	2.0	3.6



TEST 1-3A (STEAM)
AIR SIMULATOR TEST
REGION
INFLUENCED
BY
DOWNDRAFT
IN TEST
20
10
Bundle
Flow
gpm
27
33
39
45
51
57
63
69
75
81
Core radius

Column 6

CONCLUSIONS

DOUBLE HEADER COMPARISONS TO SINGLE HEADER SUPERPOSITION

- SUPERPOSITION DOES NOT APPLY FOR ALL LOCAL BUNDLES
  - SIMILAR RESULTS FOR AIR AND STEAM COMPARISONS

- SUM OF SINGLE HEADER VALUES IS GOOD ESTIMATE OF CORE MINIMUM FLOW FOR DOUBLE HEADER
  - CONSISTENT FOR AIR AND STEAM COMPARISONS

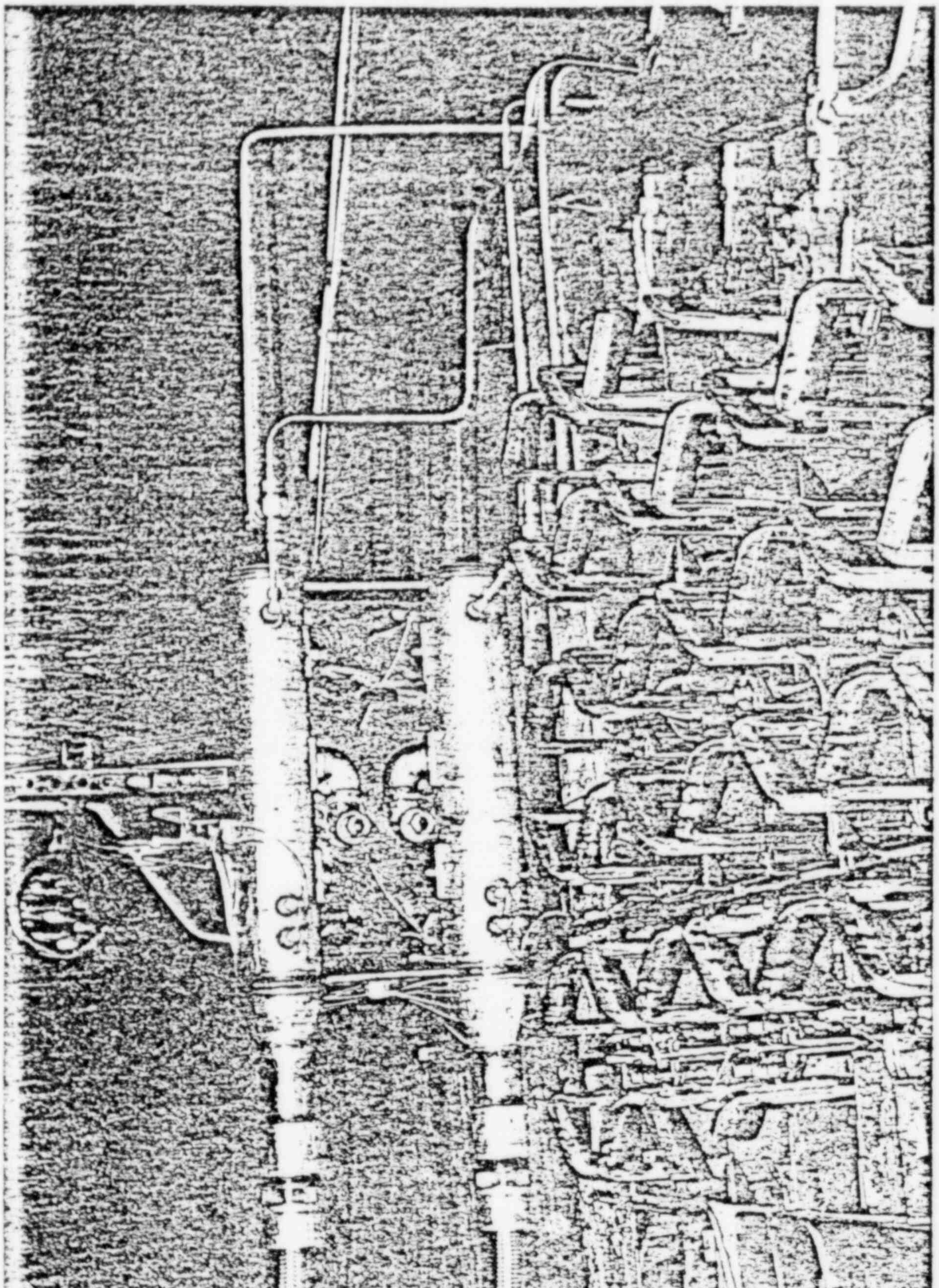
QUESTION

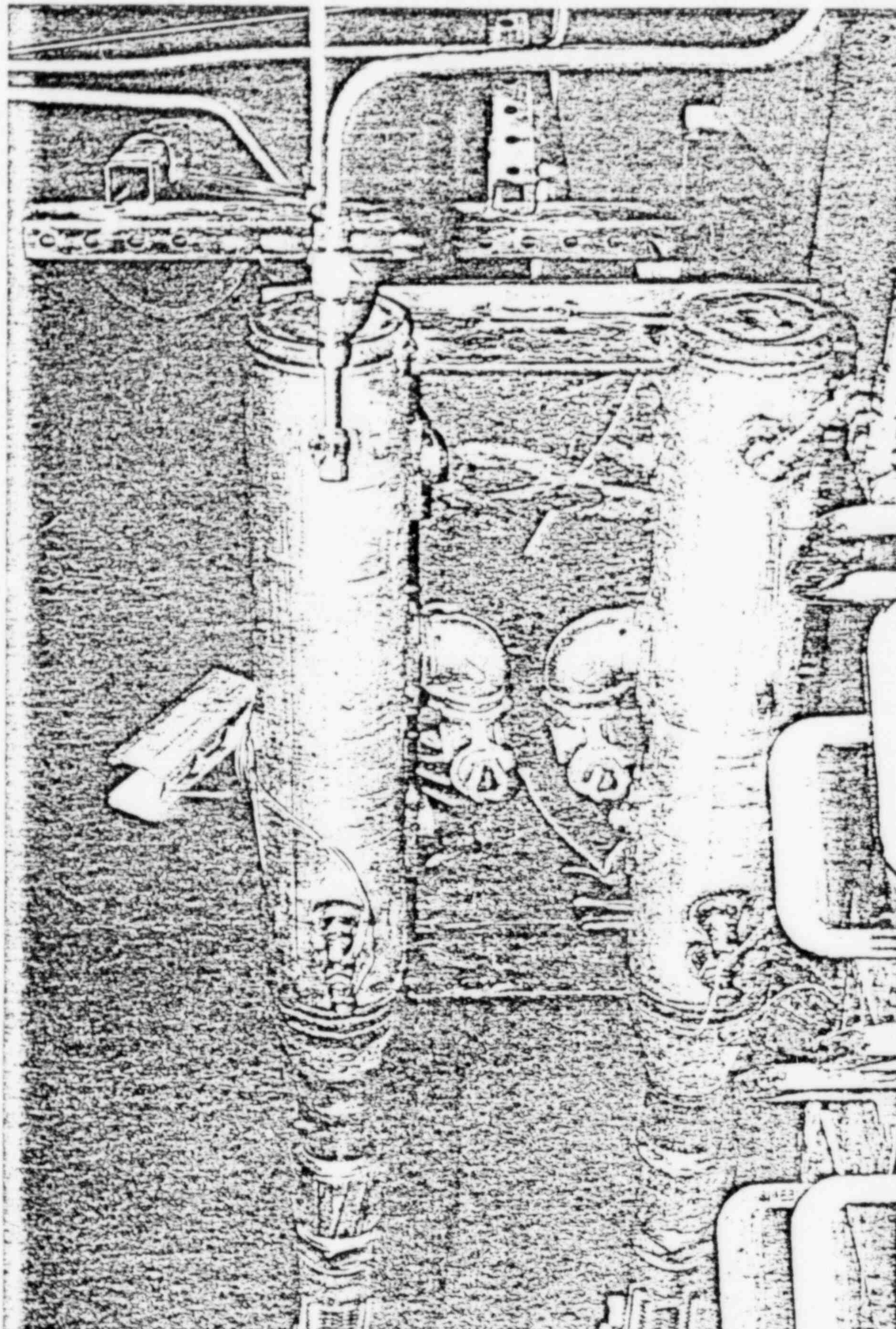
HOW CAN METHODOLOGY BE APPLIED TO BWR/4,5 DOUBLE HEADER OPERATION WHEN NOZZLES ARE CLOSE TOGETHER?

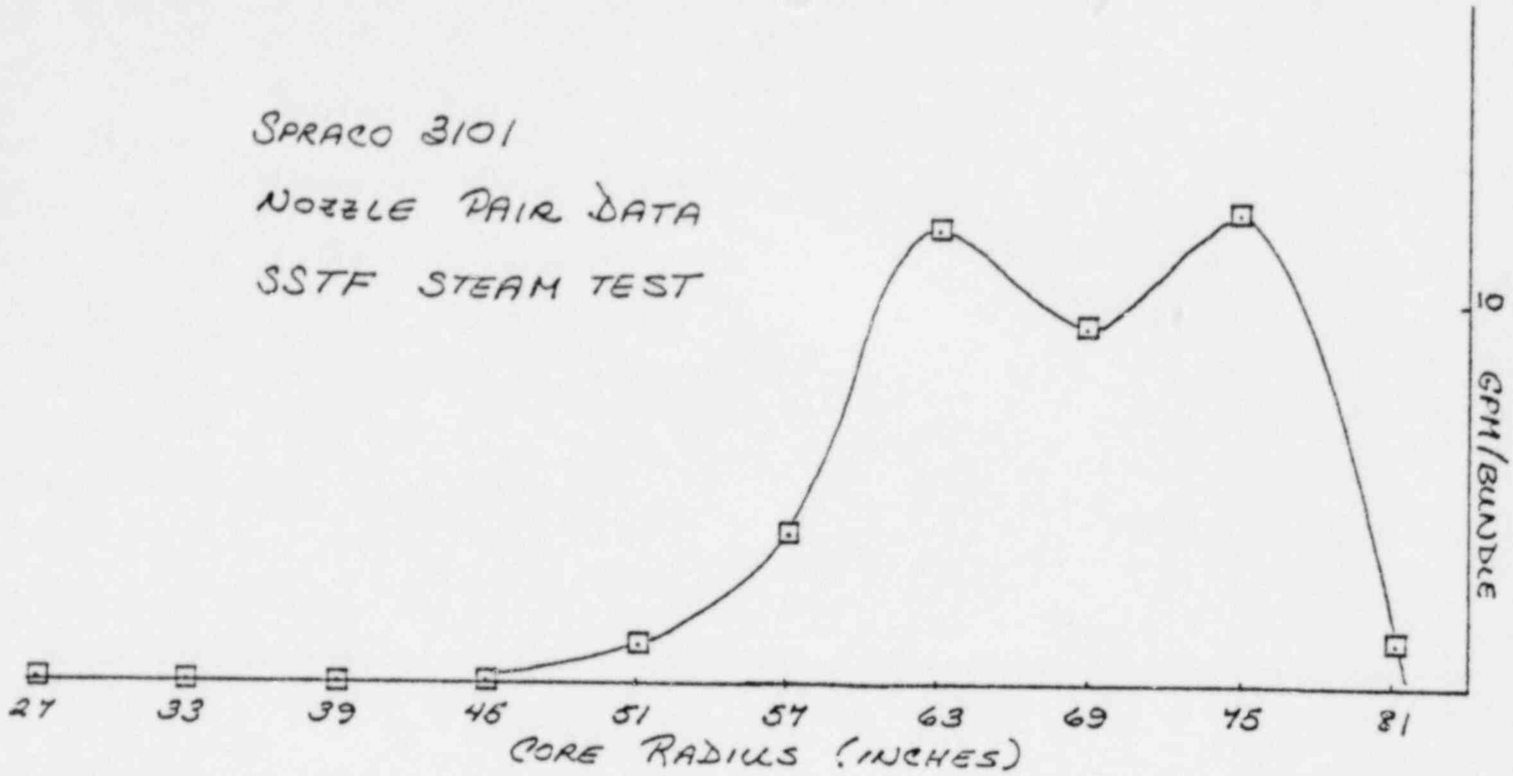
ANSWER

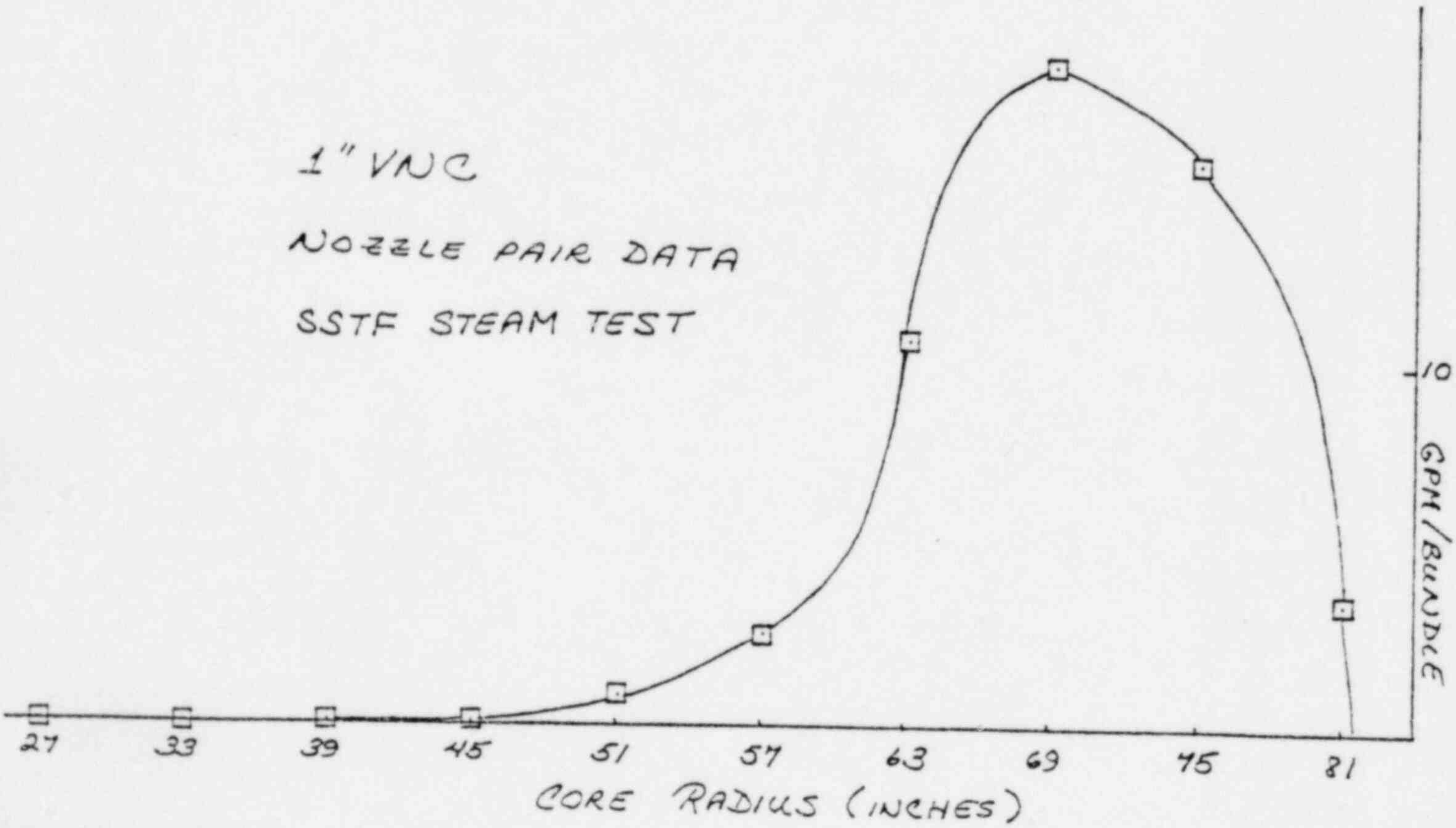
WHEN TWO NOZZLES INTERACT IN THE CONDENSING REGION CLOSE TO THE NOZZLES, THEY NEED TO BE TESTED TOGETHER IN STEAM AND TREATED AS A "SINGLE NOZZLE" FOR THE METHODOLOGY. SUCH NOZZLE-PAIR TESTS HAVE BEEN CONDUCTED FOR THE CLOSE VERTICAL-SPACED NOZZLES OF THE BWR/4-5 DOUBLE HEADER. THE RESULTANT DISTRIBUTIONS SHOW VERY LITTLE EFFECT FROM CONDENSATION IN THE INTERACTION REGION, AND CONFIRM THAT THE METHODOLOGY CAN BE DIRECTLY APPLIED USING THE NOZZLE-PAIR APPROACH.

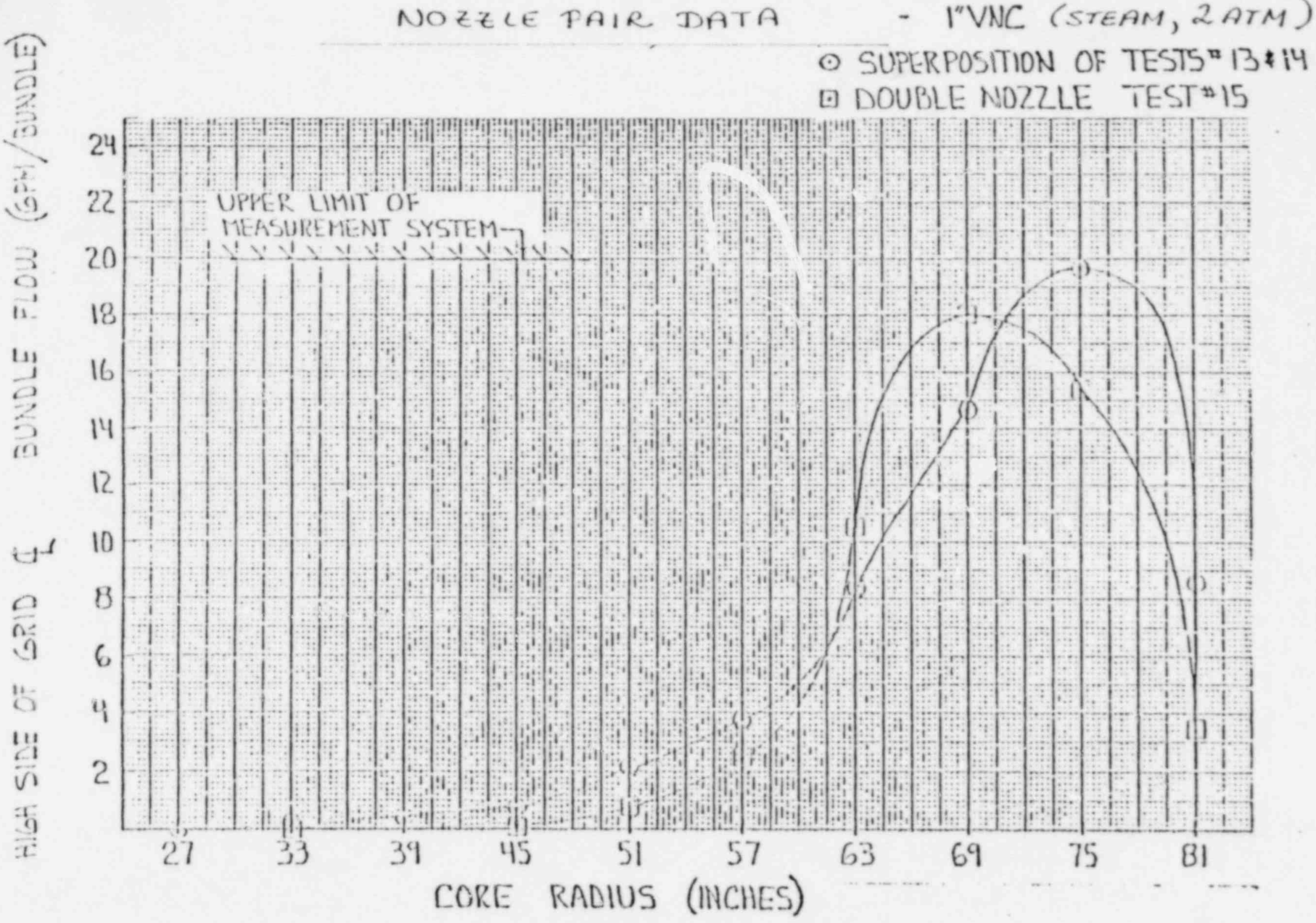
PHOTOS OF DUAL NOZZLE
TEST ASSEMBLY



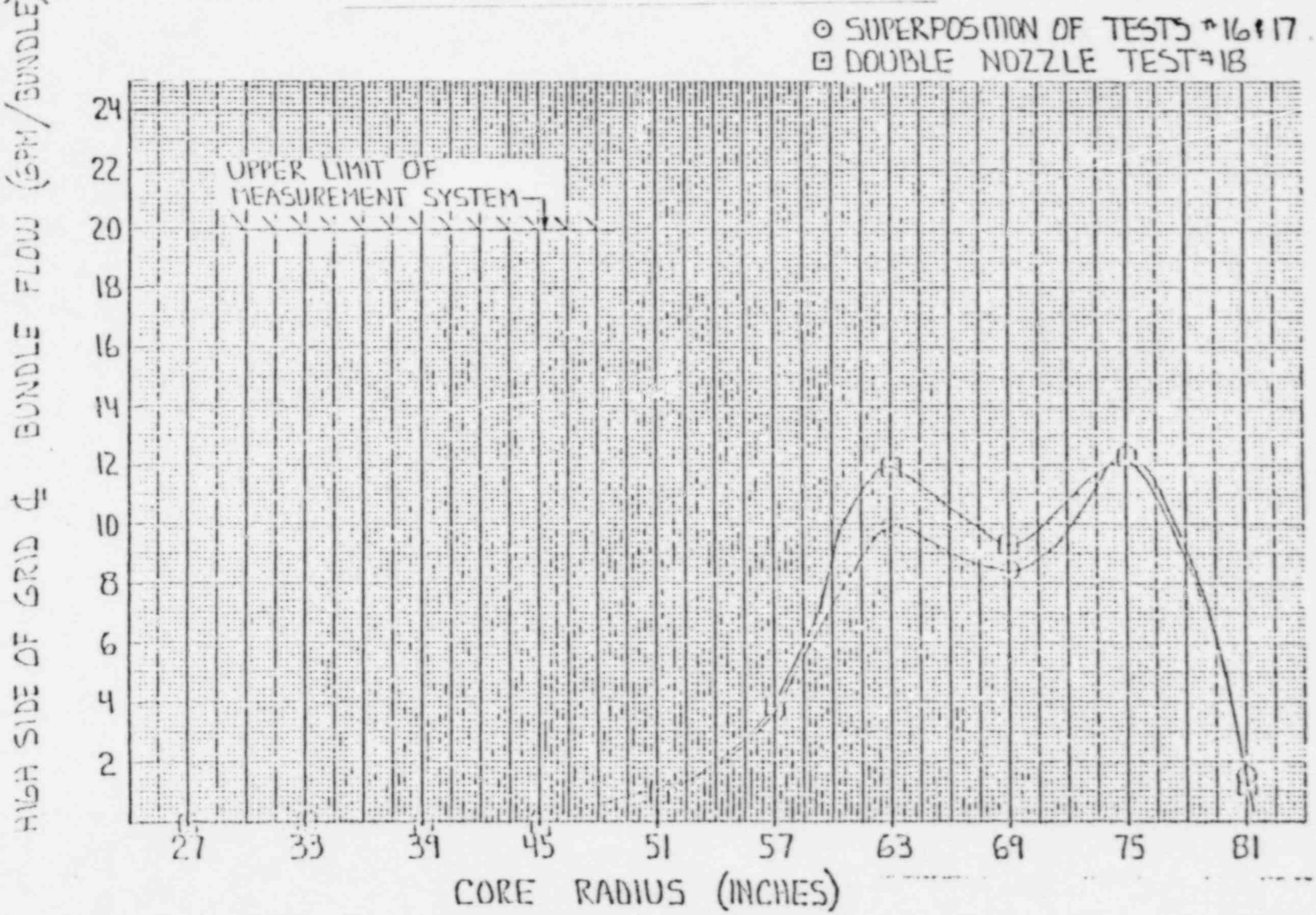



SPRACO 3101
NOZZLE PAIR DATA
SSTF STEAM TEST
10
GPM/BUNDLE
27
33
39
46
51
57
63
69
75
81
CORE RADIUS (INCHES)


1" VNC
NOZZLE PAIR DATA
SSTF STEAM TEST
10
GPM/BUNDLE
27
33
39
45
51
57
63
69
75
81
CORE RADIUS (INCHES)


NOZZLE PAIR DATA - 1"VNC (STEAM, 2 ATM)
⊙ SUPERPOSITION OF TESTS # 13 & 14
⊡ DOUBLE NOZZLE TEST # 15
UPPER LIMIT OF MEASUREMENT SYSTEM
HIGH SIDE OF GRID ℄ BUNDLE FLOW (GPM/BUNDLE)
24
22
20
18
16
14
12
10
8
6
4
2
27
33
39
45
51
57
63
69
75
81
CORE RADIUS (INCHES)
1

NOZZLE PAIR DATA - S3101 (STEAM, 2 ATM)



CONCLUSIONS

USE OF METHODOLOGY
FOR BWR/4,5 DOUBLE HEADER

- APPROPRIATE DESIGN OF SIMULATORS NEEDED
- TREAT DOUBLE HEADER AS A PSEUDO SINGLE HEADER
- REST OF METHODOLOGY USED AS FOR BWR/6