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OCT 0 4 1982

Docket No. 50-447

MEMORANDUM FOR: Ashok Thadani, Chief
Reliability & Risk Assessment Branch
Division of Safety Technology

FROM: L. G. Hulman, Chief
Accident Evaluation Branch
Division of Systems Integration

SUBJECT: Q1 FOR GESSAR PRA REVIEW

Attached are AEB's first round of questions concerning the GESSAR PRA. Incorporated in our questions are the views of our consultant, A. Postma. The review was conducted by J. Mitchell, J. Read, and W. Pasedag.

With respect to the question of a potential shortening of the PRA review schedule, it should be noted that AEB's review of the source terms used in the GESSAR PRA is severely hampered by a lack of a complete report describing the GE suppression pool scrubbing experiments. Although GE's final conclusions concerning their experiments were announced in a letter to H. Denton this spring, GE still has not supplied a complete description of the tests for our review. The appendix to the PRA on the GESSAR docket appears to be an excerpt, or summary, of a complete report, and does not contain the necessary information for an assessment of the findings of the experiments. In view of this delay in providing the supportive information, we believe it may be inappropriate to discuss a contraction of the PRA review schedule.

Nevertheless, AEB could, at the cost of delay in other OL and OR reviews, provide an expedited review of the requested information, once submitted in approximately 6 months from the time of receipt. Incorporated within this 6 months effort is provision for GE's response to the enclosed questions. If GE is able to accelerate their responses, a corresponding reduction in AEB review time may be possible. This effort would produce input to consequence analysis (CRAC calculations) no sooner than April, 1983, so that Q2 on consequence calculations could be transmitted in early April 1983.

Original signed by

L. G. Hulman, Chief
Accident Evaluation Branch
Division of Systems Integration

Enclosure:
As stated

cc: R. Mattson, J. Mitchell
R. Houston, A. Postma
S. Hanauer, J. Read
D. Eisenhut, W. Pasedag
M. Ernst, J. Meyer, RSB
T. Novak, D. Meyer, CPB
C. Thomas, D. Yue
D. Lynch

*See Previous Concurrence Sheet

OFFICE			DSI:AEB*	DSI:AEB*	DSI:AEB	
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DATE			10/ /82	10/ /82	10/ /82	

AEB QUESTIONS ON GESSAR PRA

1. The most significant departure from current PRA source term estimate appears in the credit assumed for the scrubbing of fission products in the suppression pool. The assumptions are based almost entirely on the GE pool scrubbing experiments. However, no complete reporting of these experiments is available either on the GESSAR docket, or in the open literature. The description in Appendix 15D appears to be an excerpt, or a summary, of the experiments. It is lacking in such essentials as a complete description of the experimental apparatus, instrumentation, experimental conditions (for all tests) and test data. Please provide a complete reporting of these experiments, as they are crucial to the assessment of accident source terms. The following questions on the abbreviated material available will indicate the type of information necessary for our review.

1.1. Scaling of the hydrodynamic processes governing gas flow into the suppression pool by way of the SRVs and vent pipes is reasonably well understood. Please provide a scaling analysis that demonstrates that to the conditions for the scrubbing experiments are indicative of the hydrodynamic conditions anticipated in the prototype.

(a) Include therein a discussion of how the effect of surface tension is scaled so that bubble break-up is properly accounted for.

(b) Once the bubble sizes are rationalized, pool depth and terminal velocities of single bubbles and swarms of bubbles must be considered. Provide a discussion of the scaling considerations employed for the test facility that account for the pool height to bubble velocities ratio time scale.

(c) Bubbles break through a surface by a complex process that creates small liquid droplets that are thrown upward. The amount of entrained liquid will be a function of the bubble size and how many of them there are. Scale will play an important role here also; please discuss.

1.2. The DF prediction focuses on iodine present as CsI associated with large particles. What would be the effect of assuming some elemental iodine or organic iodine? What would be the potential for formation of organic iodine in the drywell? To what extent would elemental and organic iodine forms limit decontamination factors?

1.3. Particle size is an overriding factor in your model. How can we predict with assurance particle size distributions under accident conditions? (See also the following detailed questions for concerns relating to the particle size distributions in the experiments.)

1.4. What shape factor should be used to characterize the Eu_2O_3 in the depletion calculation? Please provide justification for your conclusions.

1.5. Considering the sensitivity of DF to particle size, the determination of an average size of 4.1 μ cannot be considered close agreement with the stated "1.87 to 3.1 μ determined by the Quantamet." Which of these values is close to the actual expected value, i.e., a better representation of reality. Which one did GE use? How does what GE used compare with either of these values?

1.6. Provide examples of the scanning electron microscopic pictures referred to on Page 49-C33.

1.7. What effects do deposition and reentrainment have on the particles as they actually enter the pool, compared to measurements made at other times or places.

1.8. Show on a copy of Figure 1-2, and discuss, the effect on the experiment of the diluter mentioned on Page 49-C34.

1.9. What are the length to diameter ratios for all the sampling lines? What effect or modification will this factor have on the measured size of particles? Will there be any appreciable expected tendency to deposit for lines of large 1/d?

1.10. Page 49-C33 discusses 2 impact samplers. Figure 1-2 shows 3 (before the pool, above the pool, and after the recirculation line). Which two are meant to be referenced in the text? What does the third one sample?

1.11. The last line of Page 49-C35 states that a "high flow recycle stream" kept particles in suspension. What was the magnitude of the flow in cfm, and what velocities existed in the recycle circuit?

1.12. Tables 15 DA.1-1 and -2 give what seems to be a calibration for the impactors used. Is this what they are? How are the particle diameters in the table defined? Give the equations used in the calculation and a reference therefore. Which 2 of the 3 impactors are referenced in the tables? Are the calibration conditions typical of the flow rates in the actual experiments?

1.13. There was in the presentation by a GE representative to the American Chemical Society in Kansas City in September, 1982, a statement that the impactor at the top of the tank may have modified the particle size. Is this GE's position? If so, why might this same condition not have occurred on either of the other 2 samplers? How would the comparison of the experiment with the model be changed?

1.14. The paragraph at the top of Page 49-C36 seems to indicate that all starting and final locations of Eu_2O_3 were sampled. This should allow a mass balance to be performed. Did GE do this? If so, what are the results? If not, what places remained unaccounted for?

1.15. On Page 49-C37 an "entrance effect" is discussed. What is your definition of an entrance effect? How was it calculated? Is it a function of particle size? Give a reference. How are values given in Figure 15 DA.1-3 (curves or data) modified for this effect?

1.16. The same page refers to the particle size distribution in Table 15 DA.1-5. The table purports to contain fractions of mass of Eu_2O_3 vs average particle size. The mass fractions do not add to unity. What is the particle size distribution? Considering the extreme sensitivity of DF to particle size, are the bins of particle sizes in that table sufficiently small so as not to cause uncertainty in DF assumptions? Give sample calculations. Since only one size distribution is given, is it correct to assume that all the many experiments had exactly the same size distribution? Were the distributions not measured by the impact samplers in every experiment?

1.17. How do you get the correct diameter to calculate the Cunningham slip factor and the diffusivity, if an assumed value is input for the density? How much uncertainty can be introduced in the calculated DF as a result?

1.18. In Paragraph (2), on Page 49-C38, the statement was made that the experimental results exhibited the trend of DF versus particle size given by the model. No data are given which would allow this to be reviewed. Provide the data and the comparison.

1.19. Paragraph (6) on 49-C40 discusses the water as a perfect sink. The statement is made that water will absolutely absorb the particle (Emphasis added). Provide references or supporting data for this absolute statement.

1.20. Paragraph (7) on Page 49-C41 states that super-heated steam could play an important role in promoting particle growth. Discuss the mechanism by which this takes place. Provide references or other supporting information.

1.21. Paragraph (8) on Page 49-C41 states that the scrubbing factors are conservative from a temperature standpoint because thermophoresis was neglected. Thermophoresis would, if calculated, increase the DF. However, there is an effect in the opposite direction, diffusophoresis. This effect may be larger than thermophoresis. Show why the DFs should be considered conservative.

1.22. In table 15DA.1-4, data are given for tests on 12/11, 12/14, and 12/15. Given GE's model, these tests would all be expected to give the same results. There is over a factor of 4 difference in the results, however. Does this represent scatter in the data? Explain.

1.23. Provide justification for the statement on Page 49-C43 that the large bubble shatters within about one bubble radius, especially considering the statements on Page 49-C45, 2nd paragraph. In the justification, consider especially problems of scale.

1.24. Justify the submergence of 3 and 5 feet used in the experiment from the point of view of scale. What are the minimum, maximum, and average submergency values of the horizontal vents in the within-plant case?

1.25. For Figure 15DA.2-3, what is the basis for the solid curve? It does not appear to be a "best fit" to the data. Was the parameter bubble rise velocity as a function of flow rate used in the analysis? If so, please present the values used and justify. Is the "bubble rise velocity" really the swarm velocity, or is it measured for the first 1-3 bubble radii?

1.26. In Equation (7) on Page 49-C50, should there not be a factor for acceleration due to gravity reflection of Taylor instability theory over the range of wave length possible? Further, this equation is not applicable to determination of a stability threshold as implied in the last sentence of that paragraph; please discuss.

1.27. Charge of the particles, due for instance to decays during the transit of the pool, has not been evaluated as a difference between the tests and actual accidents. Discuss.

1.29. Entrainment from the pool has been neglected. Justify.

1.30. We understand that some experiments were performed with CsI. Is this true? If so, provide the data and their evaluation.

2. The GE model to describe DF's achieved by suppression pool aerosol scrubbing has several variables that appear in the exponent of an exponential expression. Provide the expected uncertainty band for each parameter in the exponential term and discuss the sensitivity of the DF to these uncertainty bands.

3. Justify not considering the evolution of iodine from the pool due to such processes as radiolysis.

4. GE's model does not appear to differentiate between bubble rise velocity and swarm rise velocity. We believe this distinction is an important one, in that it has an effect on calculated DF values. Please clarify the terms used for diffusion and inertial removal, and justify the velocity used.

5. After the change to the central estimate dose model (letter dated July 16, 1982) the comparison with WASH-1400 composite site and GE calculation of site 6 show large factors of disparity (See Table 7.2-1). Does GE still wish to justify site 6 as an average site? If so, provide the justification. If not, state the types of sites for which the PRA will be applicable.

6. Since GE expects that the particle size distribution of a core aerosol will be significantly modified by passage through the pool (due to orders of magnitude differences in GE's DF versus particle sizes), provide a review of dose conversion factors and expected consequences, considering that penetrating aerosols will be preferentially emitted.

7. The discussion (p.15.D.3-569) of DF's assumed for plugging of drywell or containment cracks states that the values used ranged from 1.0 to infinity. Please be a little more precise concerning the values used. Discuss the crack size and particle size assumed. Provide a basis for your assumptions and discuss the applicability of the Morewitz model. (Note that the results of the Marviken containment tests (1974) directly contradict the Morewitz model predictions). Discuss the significance of other leakage paths bypassing the suppression pool in this context.

8. The PRA consequence calculations are purported to be realistic, or somewhat conservative. The evacuation delay assumption for the CRAC analyses, however, is that full-scale mass evacuation preparations can be accomplished instantaneously. This is neither realistic nor conservative. Please discuss the effects of a realistic (non-zero) estimate of evacuation delay times.

EPRI/GE/PNL MEETING

NAME	ORGANIZATION	TELEPHONE #
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DD JONES	GE - Engineering	408-925-6896
R.I. SCHRECK	PNL	509-376 [illegible]

YU 2/28/83

PNL

EPRI/GE/PNL MODEL-DATA COMPARISONS

FEBRUARY 28 MEETING AGENDA

A. IDENTIFICATION OF POSSIBLE REASONS FOR DIFFERENCES ARISING FROM RECENT GE MODEL-DATA COMPARISONS
(Based on EPRI/BCL and GE data and SPARC-B code).

- Error in Using Code
- Code Errors/Mechanisms Omitted
  - Condensational Growth Model
  - Entrance Effects
  - Other errors/omissions
- Differences Concerning Inputs
  - Particle Solubility GE
  - Bubble/Swarm Rise Velocity
  - Bubble Size/Shape
  - Handling of Particle Size Distribution
  - Other Differences
- Data Errors
  - Particle Size Distribution Measurements
  - Mass Balance?
  - Entrance Velocity?
  - Possibility of Holdup?
  - Other Measurement Errors.

B. ADDITIONAL DATA

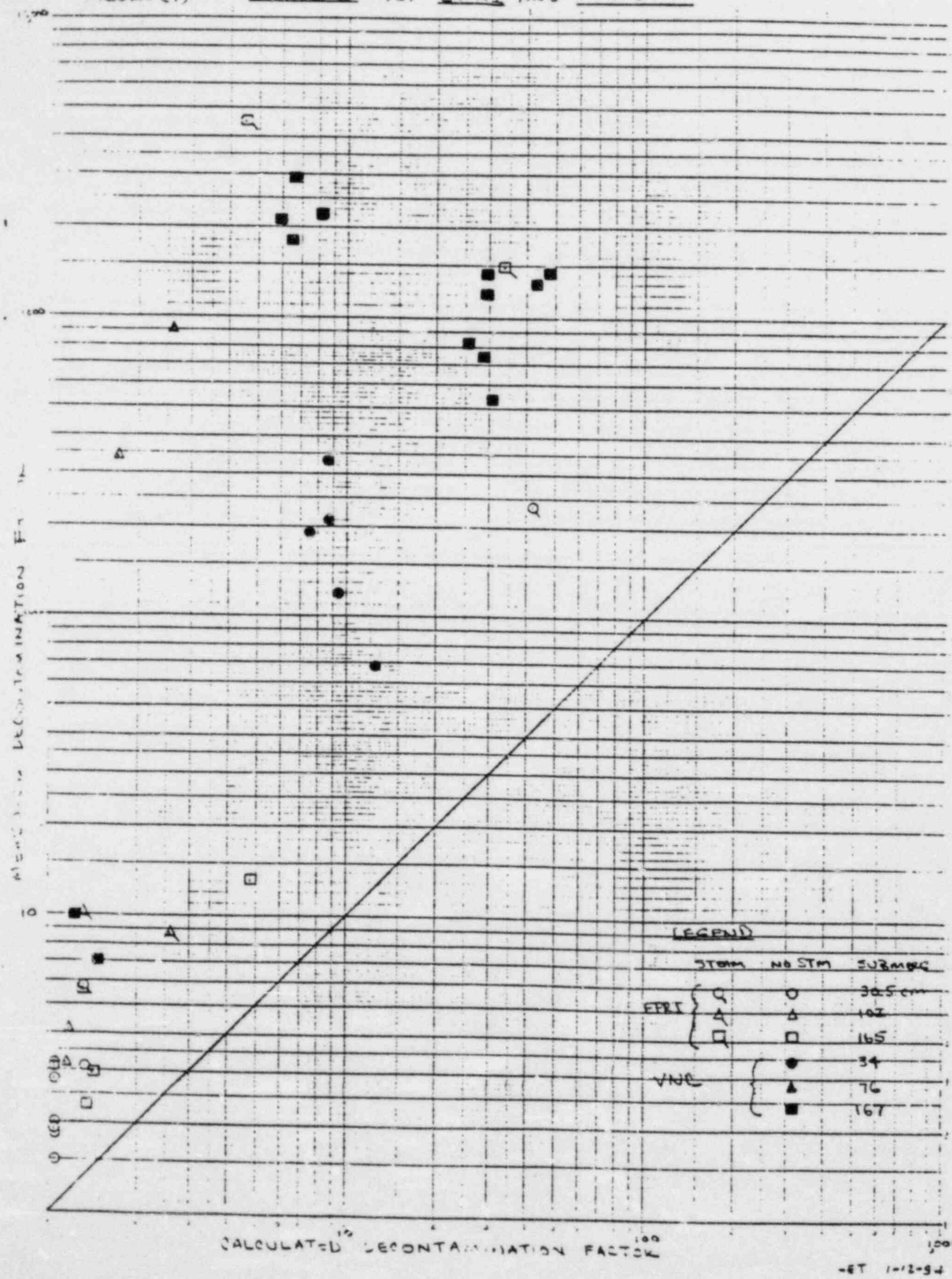
- GE has additional EPRI/BCL particle size info.
- Other useful info. from EPRI/BCL tests, e.g., exit gas flow rates
- Latest info. from sat'd pool tests - can wall and pool effects be separated?
- GE data used to validate GE model?

C. FUTURE VERIFICATION/VALIDATION EFFORTS

- Additional EPRI/BCL data - ongoing
- Use of SPARC C, D, ...Z.
- Modeling of EPRI/BCL tests req'd to separate effects?
- Use of SPARC/SUPRA/GE Model to work same problem(s).
- Additional Tests?
- Publication of GE Test Data - Validation Effort? YES

① GE COMPARISON

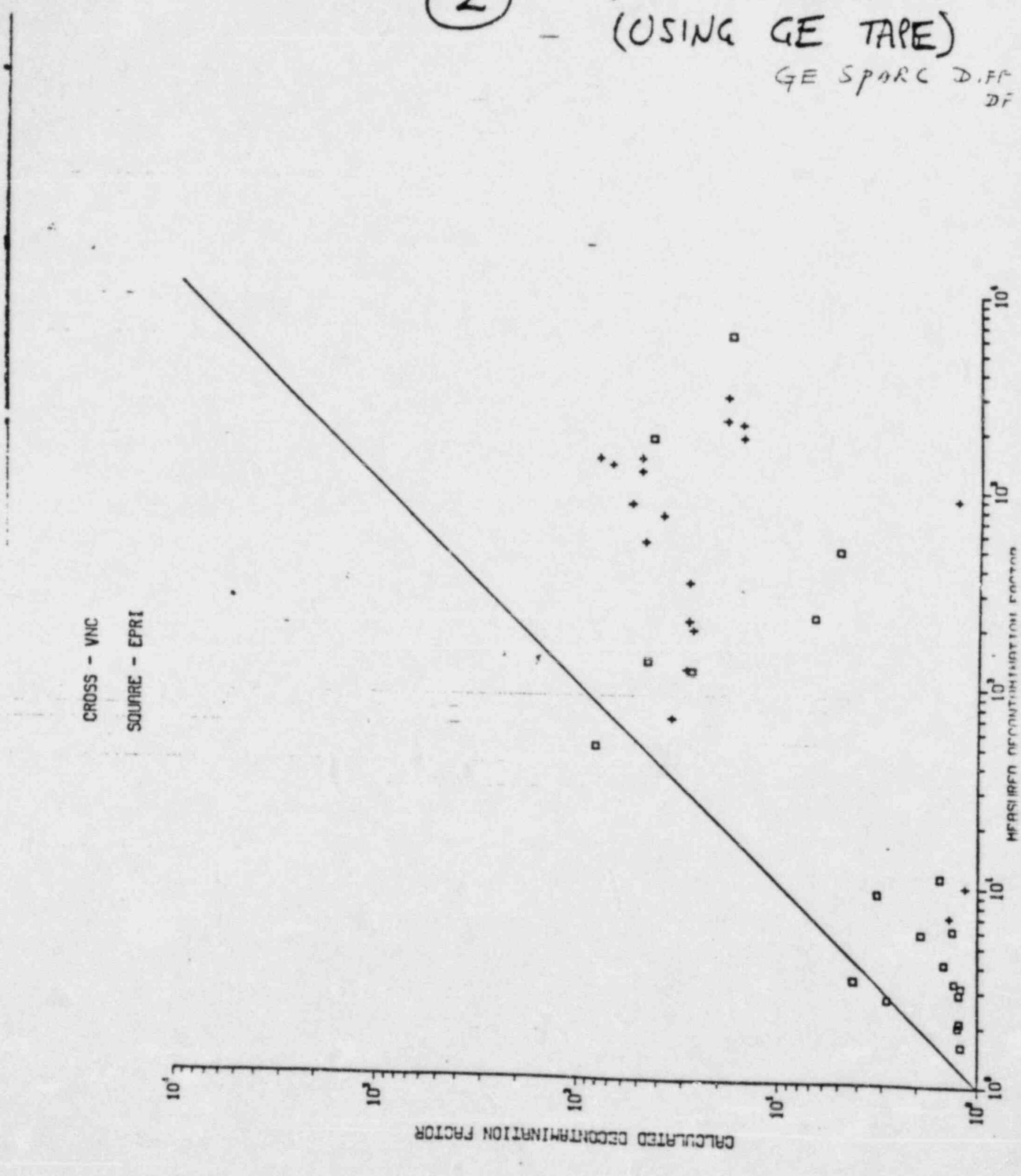
FIGURE (1) SPARC-B vs. EPRI AND VNC DATA



-ET 1-12-94

(2) PNL CALCULATIONS – (USING GE TAPE)

GE SPARC D.F / DF



(3)

all "air" noncondensible

EPRI/[redacted]
/BCL

PNL

Run	Date	Total Flow (g/s)	T_{gas} (°K)	Aerosol Inj Rate (10^{-7} kg/s)	Depth (M)	T_{pool} (°K)	DF_A	DF_B	
(1)	1/18/83	0.25	283	4.25	.305	283	2.9	2.9	
(7)	1/18/83	9.86	283	2.57	.305	283	1.7	2.2	
(13)	3/2/83	2.35	292	6.95	.305	292	3.0	3.3	
16	3/3/83	9.69	291	5.17	1.02	291	6.0	5.4	
(19)*	3/17/83	5.91	294	2.55	1.65	294 21	4.0	2.7	1.5
(22)	12/20/83	2.33	283	11.3	1.65	279	7.1	4.5	
(55)	12/22/83	0.49	292	9.58	.305	279	2.4	1.6	
(58)	1/18/83	2.33	283	10.8	.305	283	2.6	1.4	
(58)	1/20/83	2.33	282	12.5	.305	282	2.0	1.2	
(58)	2/9/83	2.42	295	9.33	.305	295	2.2	2.3	
(64)*	3/7/83	0.49	283	5.67	1.02	293	3.9	2.7	1.08
(70)	12/20/82	8.8	283	5.44	1.02	293	4.4	3.8	
(76)*	3/16/83	2.45	291	9.83	1.65	291	14.8	10.5	8.4
(79)*	3/16/83	9.97	291	3.03	1.65	291	2.9	2.5	1.4
1 He*	5/6/83	0.23	291	11.3	.305	291	1.8	2.4	
1 He*	5/13/83	0.23	293	4.6	.305	292	5.9	3.1	
1 He*	5/24/83	0.23	295	7.28	.305	291	3.4	1.7	
58 He*	6/6/83	0.41	294	7.75	.305	294	7.6	5.7	
64 He*	5/11/83	0.24	291	5.42	1.02	291	3.7	2.1	
107 He*	6/7/83	0.46	294	8.17	1.02	293	12.8	13.1	

* PNL HAS SIZE DISTRIBUTION DATA FROM EPRI/BCL.

O GE HAS CALCULATED DF FOR CIRCLED RUNS (PG. 6)

A, B DIFFERENT WAY TO MEASURE DF

EPRI/BCL

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proprietary

MASS DISTRIBUTION IN PERCENT BY DIAMETER

Run	Date	Steam Mass Fraction	Total Flow (g/s)	T_{gas} (°K)	Aerosol Inj Rate (10^{-7} kg/s)	Depth (M)	T_{pool} (°K)	DF_A	DF_B	
5	12/17/82	0.15	5.03	365	8.40	.305	290	3.1	2.9	
5a	1/25/83	0.15	5.03	366	2.87	.305	288	5.0	6.1	
6	1/24/83	0.96	7.19	375	5.16	.305	289	260	185	
21 *	3/11/83	0.95	5.93	393	3.72	1.65	373	330	280	
26 *	3/11/83	0.54	9.09	377	8.62	1.65	373	291	125	
27	1/21/83	0.94	7.30	374	7.72	1.65	291	1600	1920	CsI
62 *	3/4/83	0.60	11.47	366	5.30	.305	374	18.5	18.3	
63	2/11/83	0.94	7.35	374	4.91	.356	374	790	600	
68	12/9/82	0.43	1.78	375	5.07	1.02	283	8.6	9.2	
69 *	3/9/83	0.93	1.55	375	3.37	0.305	294	135	100	
34	9/6/83	0.	9.30	298	149.5	0.152	298	227	220	
40	9/23/83	0.	2.32	298	55.8	1.02	298	443	531	SnO
50	9/21/83	0.43	1.76	375	17.4	1.65	302	6410	5510	
74	12/2/82	0.38	0.71	374	6.07	1.65	283	9.3	9.0	
8 *	3/29/83	0.08	4.83	375	2.60	1.02	283	10.1	12.[illegible]	

EPRI/BCL

~~CONFIDENTIAL~~
proprietary

MASS DISTRIBUTION IN PERCENT BY DIAMETER

Run	Date	.097	.11	.13	.17	.22	.28	.38	.5	.66	.92	2.04
		.09-.104	.104-.118	.118-.139	.139-.20	.20-.24	μm .24-.32	.32-.44	.44-.56	.56-.76	.76-1.08	1.08-3.00
19	3/17/83	--	--	0.1	0.1	0.3	3.5	29.0	51.0	15.7	0.3	--
64	3/7/83	9.6	10.2	14.6	31.7	10.2	13.1	7.3	2.0	1.4	--	--
76	3/16/83	--	--	--	--	--	--	0.2	1.4	7.7	35.3	55.4
79	3/16/83	--	--	--	0.9	1.5	10.3	45.8	38.4	2.9	0.2	0.1
1 He	5/6/83	0.1	0.2	0.9	14.0	27.6	16.2	16.0	16.6	6.9	1.4	--
1 He	5/13/83	24.0	16.3	16.9	37.6	5.2	--	--	--	--	--	--
1 He	5/24/83	2.0	2.8	6.1	36.7	12.0	7.5	9.5	9.2	8.4	4.2	1.5
58 He	6/6/83	0.4	0.9	3.2	33.6	16.6	13.1	12.2	12.5	5.8	1.3	0.3
64 He	5/11/83	0.3	0.5	1.9	16.6	10.3	11.0	18.9	21.8	13.8	3.5	1.2
107 He	6/7/83	0.5	1.2	3.8	29.2	12.3	15.4	21.2	9.4	5.2	1.2	0.5
26	3/11/83	2.5	6.8	17.6	55.3	11.2	3.5	0.7	0.1	0.1	--	2.3
62	3/4/83	1.4	1.6	2.9	12.8	7.5	11.5	10.7	8.1	18.8	14.4	10.3
8	3/29/83	0.8	1.3	3.3	25.5	27.6	35.2	6.4	--	--	--	--

(5)

TABLE I

EPRI DATA

Test No.	Test Date	Bubble Velocity (cm/sec)	Average Measured DF	SPARC-B DF	SPARC-B* DF
1	1-18-83	57.2	2.8	1.05	2.12
5	1-25-83	89.1	5.8	1.33	2.56
5	2-17-82	89.2	3.1	1.33	2.56
6	1-24-83	99.0	233	41.1	79.0
7	1-18-83	96.7	1.9	1.05	2.01
8	3-29-83	87.1	11.1	1.32	2.64
13	3-2--83	79.1	3.05	1.05	2.05
19	3-17-83	88.8	2.95	1.42	2.97
22	12-20-82	77.2	5.65	1.30	2.80
27	1-21-83	97.5	1479	33.5	66.7
40	9-23-83	78.5	336.5	1.70	3.9
50	9-21-83	77.5	4493	4.50	11.1
55	12-22-82	62.8	1.85	1.05	2.10
58	1-18-83	78.7	20	1.06	2.05
58	1-20-83	78.6	1.5	1.05	2.05
58	2-9--83	79.6	3.15	1.05	2.05
64	3-7--83	62.7	3.15	1.16	2.51
68	12-9-82	77.5	8.7	2.59	5.31
70	12-20-82	94.7	4.1	1.18	2.32
76	3-16-83	78.2	13.15	4.76	13.74
79	3-16-83	95.6	2.3	1.35	2.75

*DF corrected for velocity and entrance effect

(7) GE

TABLE II

VNC DATA

Test Date	Average Measured DF	SPARC-B DF	SPARC-B* DF
9/16	68	12.4	79.0
9/29	330	8.6	59.7
9/30	210	8.6	59.7
10/1	120	9.3	62.2
10/8	190	7.5	55.2
10/27	1200	29.7	142.6
10/28	1400	29.7	142.6
10/30	1300	42.8	415.7
11/3	720	28.9	270.4
12/1	810	25.4	154.5
12/2	1400	47.0	221.4
12/8	530	30.7	108.9
12/9	2200	8.1	42.5
12/10	900	3.2	17.5
12/11	2900	6.6	48.9
12/14	2100	6.0	43.8
12/15	1800	6.5	43.5
12/17	10	1.2	3.7
12/18	7	1.5	5.2

*DF corrected for velocity and entrance effect

GE

```
FILE FS0068/ RGC/SVNC-001;
        01/06/84 AT    14.24101

DATA FILE   FS0068/RGC/SVNC-001
TEST NO.    1   TEST DATE    9-16
TEST DF =   68  ;   +35   -35
   24.75  SWARM VEL cm/sec
   7.42   DENSITY
   0.
   0.050E-04   0.097E-04   0.142E-04   0.258E-04   0.562E-04
   0.904E-04   1.354E-04   2.024E-04   3.276E-04   10.0E-04
   10.0E-04    10.0E-04    10.0E-04    10.0E-04    10.0E-04
   10.0E-04    10.0E-04    10.0E-04    10.0E-04    10.0E-04
    .0003       .0032       .0097       .0132       .0073
    .0084       .0400       .0780       .8400      0.
    0.          0.          0.          0.          0.
    0.          0.          0.          0.          0.
0.
0.
20.
1.037
0.
0.
.2001E-03
20.
1.0
34.3,100,2,1,4.2,40630.,0.47,1.49
 101
 0.
 20
 1.0
TEST NO.    2   TEST DATE    9-29
TEST DF = 330   ;   +570   -260
   27.71
   7.42
   0.
   0.050E-04   0.097E-04   0.142E-04   0.258E-04   0.562E-04
   0.904E-04   1.354E-04   2.024E-04   3.279E-04   10.0E-04
   10.0E-04    10.0E-04    10.0E-04    10.0E-04    10.0E-04
   10.0E-04    10.0E-04    10.0E-04    10.0E-04    10.0E-04
    .0003       .0032       .0097       .0132       .0073
    .0084       .0400       .0780       .8400      0.
    0.          0.          0.          0.          0.
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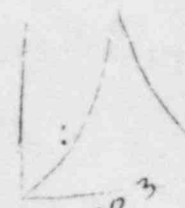

.0003 .0032 .0097 .0132 .0073 .0084 .0400 .0780 .7200 — 1.0001

.01 .10 .14 .26 .56 0.9 1.35 2.02 3.3

(8)

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- SPARC-B MODEL/DATA COMPARISONS
  1. SPARC-B From PNL
  2. SPARC-B + Entrance DF
     - Derived From EPRI Data
  3. SPARC-B + Entrance DF Actual Rise Velocity

VSWARM = F (FLOW)
116 Cm/SEC
2.5 ft/SEC
GE

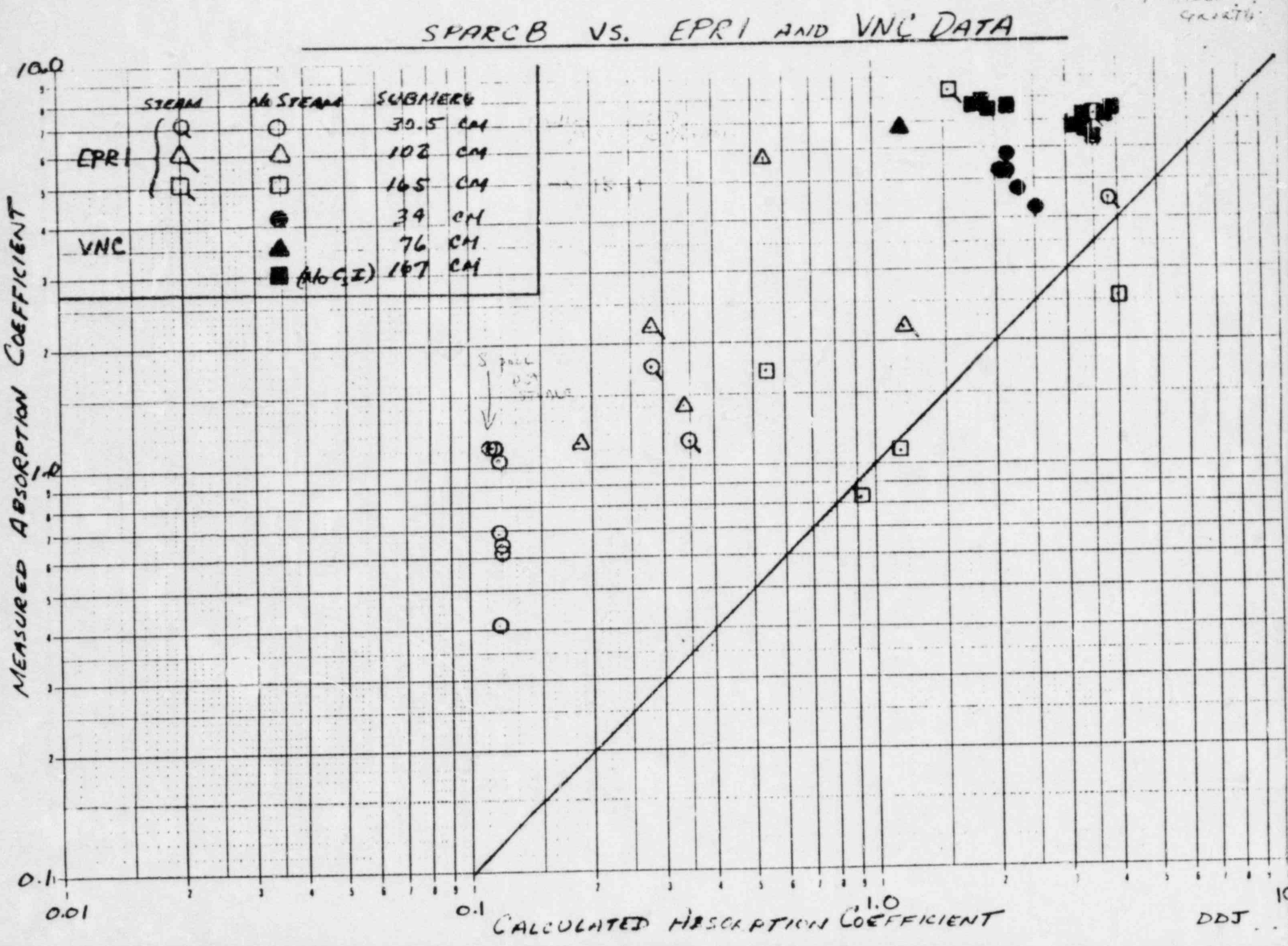
- CONCLUSIONS
  1. SPARC-B Underpredicts Most Data
     - Large Deviation At Low DF and Low Submergence (Entrance Effect Dominant)
     - Data Is For A Range Of Rise Velocities
     - SPARC-B Rise Velocity Is Greater Than Actual Velocities
     - Predictions Will Improve With Actual Velocity

- CONCLUSIONS

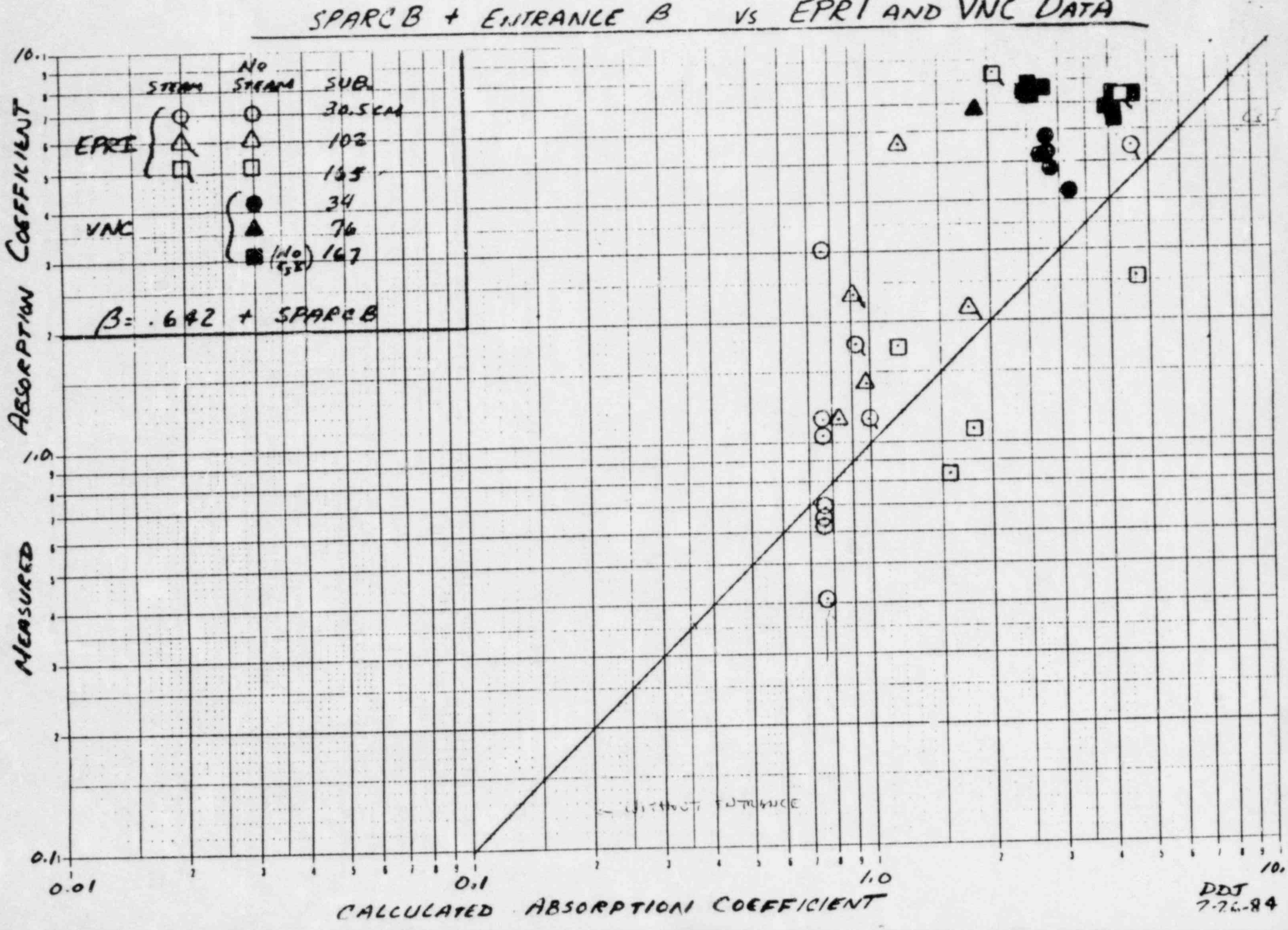
  2. SPARC-B WITH ENTRANCE DF
     - Entrance DF ~ 1.9 (ln DF = .64)
     - Large Improvement
     - Absorption Coefficient Within 1 Order of Magnitude

  3. SPARC-B WITH ENTRANCE DF + ACTUAL VELOCITY
     - Small Improvement For EPRI Data, But Important To Use Actual Velocity
     - Effect Is Small Due To Low Submergence In EPRI Data
     - Comparison With Data Generally Much Better, But Calculated DFs Are Still Low

- AREAS FOR IMPROVEMENT
  - Use Average Swarm Rise Velocity - Not Peak
  - Better Fit On Bubble Drift Velocity

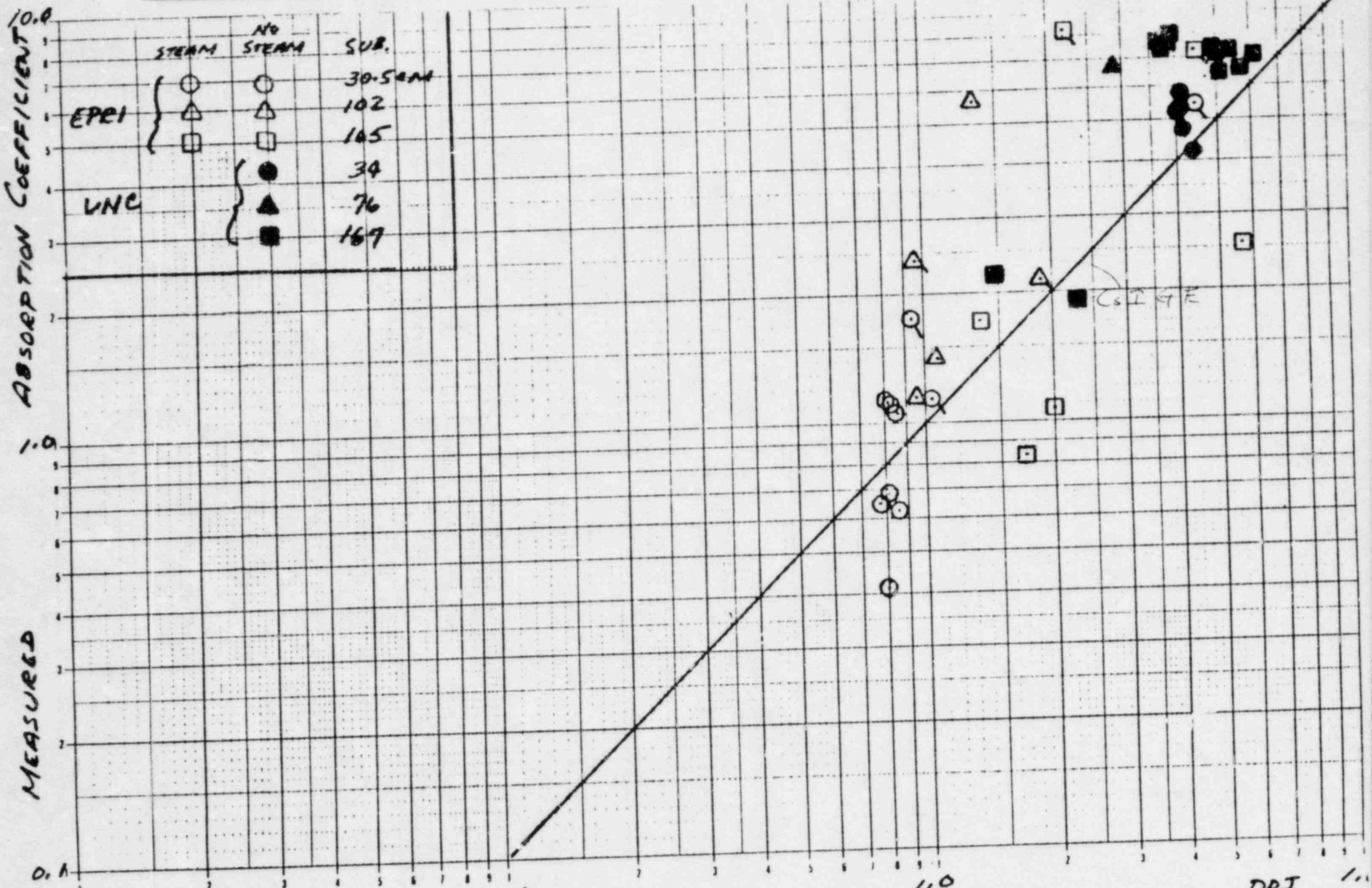


SPARCB VS. EPRI AND VNC DATA
STEAM
NO STEAM
SUBMERG
30.5 CM
102 CM
165 CM
34 CM
76 CM
(NO C_3I) 167 CM
EPRI
VNC
MEASURED ABSORPTION COEFFICIENT
CALCULATED ABSORPTION COEFFICIENT
10.0
1.0
0.1
0.01
10
DDJ



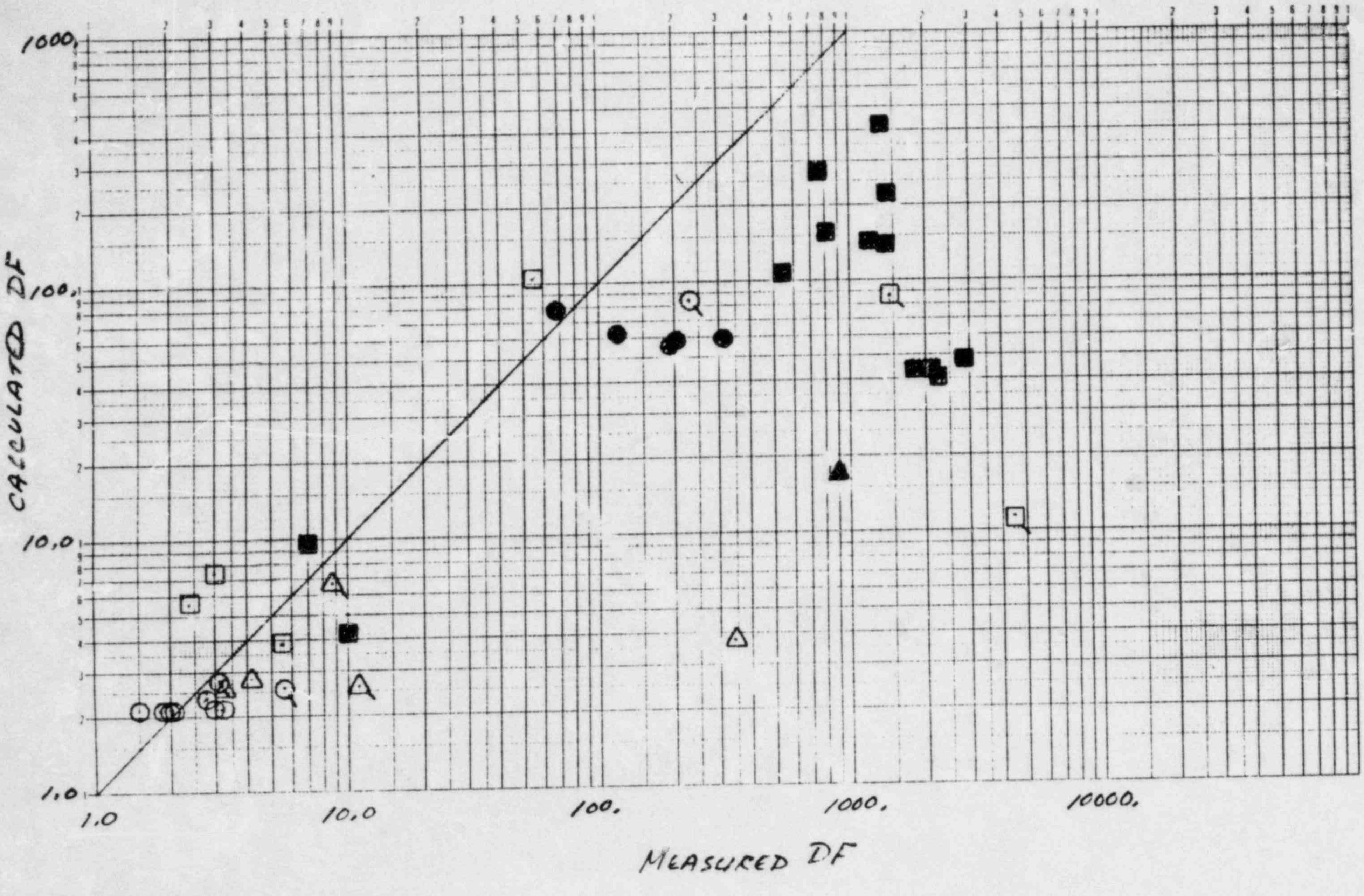
SPARC B + ENTRANCE β VS EPRI AND VNC DATA
STEAM
NO STEAM
SUB.
EPRI
30.5 CM
102
155
VNC
34
76
(No $\epsilon_s E$) 167
β= .642 + SPARC B
WITHOUT ENTRANCE
MEASURED ABSORPTION COEFFICIENT
CALCULATED ABSORPTION COEFFICIENT
0.1
1.0
10.
0.01
DDJ
7-26-84

SPARCB + ENTRANCE β + TESTED VELOCITY VS. EPRI AND VNC DATA



DDJ
2-26-84

SPARC B + ENTRANCE DF + TESTED VELOCITY VS. EPRI + UNC DATA



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GAUDAI - Chem. Eng. Sci 4, (17-28) 1955

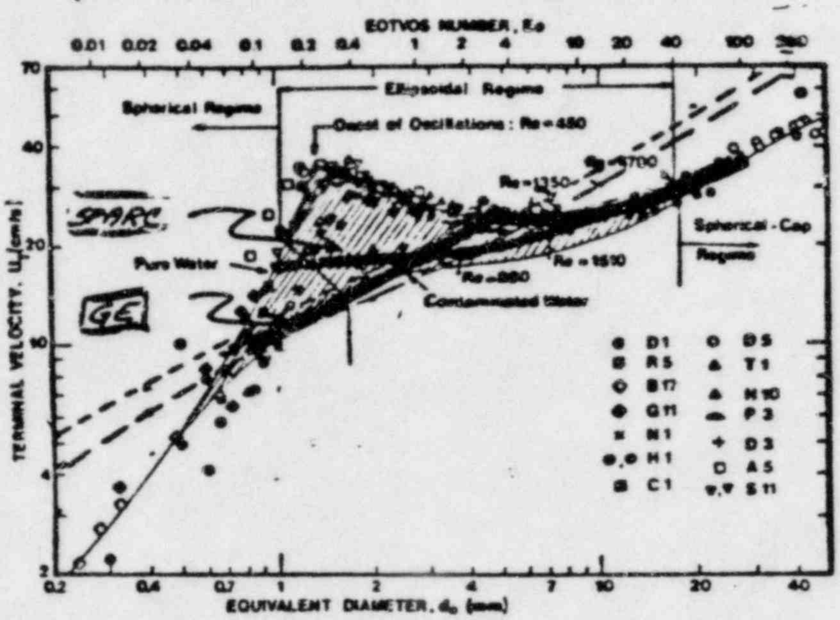
$$E_0 = \frac{\rho g d^2}{g_0 \sigma}$$

$E_0 \leq 2.62$

$$V = 1.15\sqrt{gd}$$

$E_0 > 2.62$

$$V = \left(\sqrt{\frac{2.14}{E_0} + .505}\right)\left(\sqrt{gd}\right)$$



Terminal velocity of air bubbles in water at 20 C.

CLIFT, GRACE, + WEBER