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

JUL 1 6 1979

Generic Task No. A-39

MEMORANDUM FOR: S. H. Hanauer, Director, Unresolved Safety Issues Program, NRR
R. P. Denise, Acting Assistant Director for Reactor Safety, DSS

FROM: T. M. Su, A-39 Task Manager, Containment Systems Branch, DSS

SUBJECT: SUMMARY OF MEETING HELD ON APRIL 4, 1979 WITH REPRESENTATIVES OF THE GENERAL ELECTRIC COMPANY TO DISCUSS SRV METHODOLOGY

On April 4, 1979, a meeting was held in Bethesda, Maryland with representatives of the General Electric Company. The purpose of the meeting was to discuss the methodology for predicting bubble phasing during multiple valve discharges for all Mark III containments where the GE designed cross quencher device is used in the safety/relief valve discharge line.

An attendance list and a copy of the meeting handouts are enclosed.

Background

In April 1978, the General Electric Company submitted an Interim Containment Loads Report, Mark III Containment (22A4365). Attachment M to the report provides an outline of the methodology for determining multiple safety/relief valves bubble-phasing. Since then a series of discussions had been held between GE, the staff and their consultants. Following these discussions, GE had gathered all staff concerns and provided justifications for each concern. GE, therefore, requested the meeting to discuss these justifications.

Summary

1. The bubble frequency distribution curve was generated on the basis of 132 data points obtained from tests at reactor pressures ranging from 150 to 1000 psia. Since the wide range of initial testing condition will affect the bubble frequency distribution, we requested that GE generate a bubble frequency curve based on initial testing pressure close to rated reactor pressure. In response to this request, GE presented the results of their study, which was based on selected reactor pressure and initial pool temperature. This selection criterion reduced the number of data points from the original 132 to 38. Analyses based on these selected data points resulted in a standard deviation of 1.7 Hz instead of 2.3 Hz as the original curve indicated. The mean also changes from 8.1 Hz to 8.9 Hz. Based on the

755 201

7908170240

results of this study, GE proposed a standard deviation of 1.7 Hz and a mean of 8.1 Hz as the design values. Note that the selected mean is based on all data because it results in a higher confidence level.

2. The results of the study also confirmed that line air volume is the most dominant parameter for determining bubble frequency; the other parameters such as SRV opening time, line air temperature and submergence have no statistically significant effect on bubble frequency.

3. GE will include the Caorso test results in their final analysis for predictions of bubble phasing during multiple valve actuations. The preliminary analysis indicates that the current methodology predicts conservative results when compared with the Caorso data.

4. The staff and their consultants concluded that the general approach for predicting multiple valve bubble phasing is valid. We will require, however, that GE include the following in the final analysis:

   a. Effect of pool temperature on bubble frequency;

   b. Sensitivity study of standard deviation of bubble frequency distribution and its effect on SRV loads;

   c. Effect of pool boundaries on bubble frequency; and

   d. Structural and equipment response for determining the design case.

T. M. Su, A-39 Task Manager
Containment Systems Branch
Division of Systems Safety

Enclosures:
As Stated

Distribution:

Central File
NRR Reading
CSB Reading
H. Denton
R. Mattson
F. Schroeder
R. Fraley, ACRS (16)
R. DeYoung
D. Vassallo
D. Skovholt
R. Denise
R. Martin
D. Ross
I&E (3)
NRC PDR
Local PDR
S. Varga
W. Butler
J. Kudrick
T. Su

Mark III SRV Meeting
April 4, 1979

Name	Organization
T. J. Su	NRC/CSB/DSS
P. Huber	MIT/BNL
Forrest Hatch	GE
F. Reuter	GE
P. Stancavage	GE
I. Uppal	GE
L. Sobon	GE
R. Patel	Bechtel
R. A. Hill	GE
P. Moskal	Bechtel
R. Beck	Bechtel
C. Tung	BNL
J. A. Kudrick	NRC/CSB/DSS

MULTIPLE QUENCHER METHODS

SUMMARY

P. P. STANCAVAGE
GENERAL ELECTRIC COMPANY
CONTAINMENT ENGINEERING

PPS - 1
4/4/79

755 204

VALID DATA BASE

- FREQUENCY DISTRIBUTION FROM IN - PLANT DATA
  - FULL SCALE IN TWO BWRS
  - WHOLE RANGE OF EXPECTED CONDITIONS
- DISTRIBUTION CONFIRMED AT TYPICAL CONDITIONS
  - FULL REACTOR PRESSURE
  - MODERATE POOL TEMPERATURE
  - FIRST ACTUATION
- CAORSO TEST VALIDATES DISTRIBUTION
  - FREQUENCY IS RANDOM
  - STRONG SIGNALS 5 TO 10 Hz

PPS - 2
4/4/79

FLUID - STRUCTURE INTERACTION

- GLOBAL EFFECTS SMALL
  - TORUS MODEL SHOWS NO FSI IF MINOR DIA/THICKNESS LESS THAN 600
  - LICENSEE PLANTS HAVE D/T < 600
  - MARK II/III PLANTS HAVE D/T < 300

- LOCAL EFFECTS SMALL
  - TRANSDUCERS ON CONCRETE AND STEEL SHOW SAME FREQUENCIES
  - NATURAL FREQUENCIES OF LOCAL STRUCTURES MUCH HIGHER THAN BUBBLE FREQUENCIES

PPS - 3
4/4/79

CAORSO DATA

- PRESSURE AMPLITUDES BOUNDED BY PREDICTION

- MEAN VALUES	PREDICTED	MEASURED
FIRST ACTUATION	+9.1/-6.5	+4.3/-2.8
SUBSEQUENT ACTUATION	+15.9/-9.2	+7.2/-4.5
- DESIGN VALVES	PREDICTED (90/90)	MEASURED (MAX)
FIRST ACTUATION	+12.8/-8.1	+5.0/-4.3
SUBSEQUENT ACTUATION	+29.6/-11.6	+8.0/-5.7

- TIME AND DISTANCE ATTENUATION MORE RAPID THAN PREDICTED

- BUBBLE FREQUENCY IS RANDOM
  - CYCLE TO CYCLE
  - TEST TO TEST
    INTEGRAL
    SPECIAL DENSITY
  - VALVE TO VALVE

BUBBLE PHASING

- SMALL INTERACTION EXPECTED
  - BUBBLES SEPARATED BY 5 DIA
  - INFLUENCE ONLY 10%
  - NO EFFECT ON INITIAL CYCLES
- SMALL INTERACTION CONFIRMED BY TEST
  - MULTIPLE VALVE PRESSURE BOUNDED BY SINGLE VALVE PRESSURE
    - MONTICELLO
    - CAORSO
  - MULTIPLE VALVE WAVEFORMS MIXED

CONCLUSIONS

- DATA BASE IS VALID
  - FULL RANGE OF CONDITIONS
  - CONFIRMED AT TYPICAL OPERATING STATE
  - VERIFIED BY CAORSO TESTS
- FLUID STRUCTURE INTERACTION IS SMALL
  - GLOBAL EFFECT UNIMPORTANT D/T < 600
  - LOCAL EFFECTS NOT OBSERVED
- CAORSO TESTS CONFIRM METHODS
  - PRESSURE AMPLITUDES
  - TIME AND DISTANCE ATTENUATION
  - RANDOM FREQUENCIES

755 209

MULTIPLE

QUENCHER

METHODS

NRC QUESTIONS

I. S. UPPAL
CONTAINMENT ENGINEERING
APRIL 4, 1979

755 210

QUESTION 1: DISCUSS THE STOCHASTIC NATURE OF BUBBLE FREQUENCY

RESPONSE:

BUBBLE FREQUENCY IS RANDOM DUE TO VARIATIONS IN

- o INITIAL CONDITIONS
  - LINE TEMPERATURE
  - WATER LEVEL
  - STEAM CONTENT
- o DYNAMIC PROCESS
  - TAYLOR INSTABILITY
  - BUBBLE FORMATION

EXPERIMENTAL EVIDENCE SHOWS FREQUENCY VARIATION EVEN WITH SIMILAR INITIAL CONDITIONS

755 211

SELECT DATA BASE

QUESTION 2: THE DATA WERE OBTAINED AT REACTOR PRESSURES RANGING FROM 150 TO 1000 PSIA. HOW DID THIS AFFECT THE QBF OBTAINED? A SEPARATE QBF INCLUDING THOSE DATA OBTAINED AT FULL REACTOR PRESSURE SHOULD BE GENERATED.

RESPONSE:

A SUBSET OF THE DATA BASE WAS SELECTED FROM THE IN-PLANT TESTS WHICH MOST CLOSELY REPRESENTS EXPECTED CONDITIONS FOR AN ALL VALVE ACTUATION EVENT. THE SELECTION CRITERIA ARE:

- FIRST ACTUATION, SINGLE VALVE
- POOL TEMPERATURE BELOW 110°F
- REACTOR PRESSURE ABOVE 950 PSIG

	NUMBER OF TESTS	MEAN (Hz)	STANDARD DEVIATION (Hz)	
ALL DATA MEETING CRITERIA	38	8.9	1.7	
ALL DATA	132	8.1	2.3	USE TWO SIGNIFICANT FIGURES
DESIGN USE	N/A	8.1	1.7	

THERE IS REASONABLE AGREEMENT BETWEEN SELECTED DATA AND ALL DATA.

- MEAN FREQUENCY OF DATA MEETING CRITERIA IS WITHIN TEN PERCENT OF MEAN FREQUENCY OF ALL DATA. MEAN FREQUENCY (8.1 Hz) USED IS BASED ON ALL DATA BECAUSE 132 TESTS GIVE HIGHER CONFIDENCE.

- STANDARD DEVIATION OF 1.7 Hz IS SELECTED FOR DESIGN USE
  - 1.7 Hz IS LESS THAN THE STANDARD DEVIATION BASED ON ALL DATA AND HENCE CONSERVATIVE
  - 1.7 Hz IS BASED ON TEST DATA WITH FULL REACTOR PRESSURE AND OTHER CONDITIONS THAT ARE TYPICAL OF BWR PLANTS

755 213

FREQUENCY DEPENDENCE

QUESTION 3: WAS THE QBF OBTAINED UNDER CONDITIONS OF CONSTANT AIR LINE VOLUME, VALVE OPENING TIMES, SRV LINE LENGTH AND HYDRAULIC RESISTANCE, PIPE TEMPERATURE ETC.? SEPARATE CREDIT IS TAKEN FOR THE POSSIBLE MITIGATING EFFECTS OF SOME OF THESE VARIABLES: IT IS, THEREFORE, IMPORTANT TO ESTABLISH THAT THEIR INFLUENCE NOT ALREADY IMPLICIT IN THE QBF.

RESPONSE:

THE FREQUENCY DISTRIBUTION WAS OBTAINED FROM TWO IN-PLANT TESTS WITH COMPARABLE CONDITIONS

PARAMETER	PLANT A	PLANT B	DATA MEETING CRITERIA
LINE AIR VOLUME (FT^3)	50	47	47-50
SUBMERGENCE (FT)	15	13	13-15
POOL TEMPERATURE (°F)	85-104	92-169	85-110
VALVE OPENING TIME (MSEC)	150-1000	220-1475	275-1475
REACTOR PRESSURE (PSI)	13-1066	120-1030	950-1066

VARIOUS PARAMETERS WERE INVESTIGATED VIA REGRESSION ANALYSIS FOR THEIR EFFECT ON FREQUENCY. PRESSURE RISE RATE, VALVE SETPOINT, VALVE OPENING TIME, AND BUBBLE FREQUENCY ARE INDEPENDENT VARIABLES.

755 214

RESULTS OF REGRESSION ANALYSIS

- BUBBLE FREQUENCY IS NOT INFLUENCED BY VALVE OPENING TIME OR REACTOR PRESSURE
- RESULTS SHOW NO TREND REGARDING EFFECT OF OTHER PARAMETERS ON BUBBLE FREQUENCY
- LINE AIR TEMPERATURE WAS FAIRLY CONSTANT
- LINE AIR VOLUME WAS (47-50 FT^3) CONSTANT
  - EFFECT OF VOLUME NOT IN DATA BASE
  - EFFECT OF VOLUME IS SIGNIFICANT
  - VOLUME IS INCLUDED SEPARATELY

755 215

CAORSO DATA

QUESTION 4: THE QBF SHOULD BE UPDATED ON THE BASIS OF THE CAORSO TEST AS SOON AS THESE ARE AVAILABLE.

RESPONSE:

- o CAORSO SVA DATA IS IN PRELIMINARY FORM. ANALYSIS SHOWS CAORSO MEASURED FREQUENCY IS RANDOM. CAORSO MEASURED FREQUENCY IS WITHIN RANGE OF PREDICTED FREQUENCIES.
- o TWO WAYS TO OBTAIN BUBBLE FREQUENCY
  - $F = \frac{\text{TOTAL OF BUBBLE OSCILLATION CYCLES}}{\text{TOTAL TIME OF CYCLES}}$
  - POWER SPECTRAL DENSITY PLOT (SEE FIGURES 6 & 7)
- o PSD USED TO DEVELOP CURRENT QBF
- o PSD PLOT SHOWS THAT MORE THAN ONE FREQUENCY HAS SIGNIFICANT ENERGY
- o PSD FREQUENCY SPREAD IS MUCH LARGER THAN TIME AVERAGED FREQUENCY (TABLE 4)
- o OVERALL CAORSO PRESSURE IS A FACTOR OF 2 BELOW MEAN PREDICTED

- IN TABLE 4, PREDICTED MEAN FREQUENCY

  $= 8.1 \times \sqrt[3]{\frac{50}{66.1}} = 7.4 \text{ Hz}$

- MEASURED FREQUENCY IS ONE PREDOMINANT FREQUENCY PER TEST

TABLE 4

	MEASURED	PREDICTED
MEAN (Hz)	6.05	7.4
S.D. (Hz)	± .41	1.6
LOWER BOUND (Hz)	5.3	4.6
UPPER BOUND (Hz)	6.8	10.9

- TABLE 3 SHOWS THAT EACH CYCLE HAS ITS OWN FREQUENCY

- CAORSO MVA MODEL/DATA COMPARISON UNDERWAY. THIS COMPARISON WILL SHOW THAT SRVA IS CONSERVATIVE BY A LARGE MARGIN

755 217

FREQUENCY DATA BASE

QUESTION 5: HOW WELL IS THE PROBABILITY DISTRIBUTION KNOWN? WHAT IS THE DATA BASE?

RESPONSE:

THE FREQUENCY PROBABILITY IS BASED ON 132 IN-PLANT QUENCHER TESTS AT TWO LICENSEE FACILITIES. THESE TESTS PROVIDE THE DATA FOR:

- MEAN 8.1 HERTZ
- STANDARD DEVIATION 1.7 HERTZ
- UPPER BOUND 12 HERTZ
- LOWER BOUND 5 HERTZ

A CHI - SQUARE TEST SHOWS THAT THE NORMAL DISTRIBUTION IS APPROPRIATE AT 5% LEVEL OF SIGNIFICANCE.

755 218

QUESTION 6: THE POSSIBILITY THAT THE TEST DATA (ESPECIALLY THOSE RELATING TO BUBBLE FREQUENCY) WERE AFFECTED BY FLUID STRUCTURE INTERACTION SHOULD BE ADDRESSED.

RESPONSE:

GLOBAL FSI EFFECTS

- APPLIED SRV FORCING FUNCTION TO A COUPLED FLUID STRUCTURE MODEL OF MARK I TORUS
- MODEL SHOWED FOR MINOR TORUS DIAMETER TO SHELL THICKNESS (D/T) RATIO UP TO 600, FSI IS NEGLIGIBLE
- PLANTS A & B $\frac{D}{T} \sim 600$. CONCLUSION OF REFERENCED STUDY IS APPLICABLE
- HENCE GLOBAL FSI EFFECTS IN PLANTS A & B ARE NEGLIGIBLE

LOCAL FSI EFFECTS

- LOCAL STRUCTURAL INFLUENCE IS SHOWN BY TRANSDUCERS AT DIFFERENT LOCATIONS
- FIGURE 10 SHOWS THE LOCATIONS OF PRESSURE TRANSDUCERS DA 13, 14, & 16
- FIGURE 11 SHOWS THAT EACH HAS A BUBBLE FREQUENCY ~8 Hz
- THEREFORE, THIS IS A GENUINE BUBBLE FREQUENCY, NOT AFFECTED BY LOCAL FSI

FREQUENCY DATA FROM TYPICAL PLANTS

- ADDITIONALLY PLANTS A & B ARE TYPICAL OF MARK II AND III PLANTS. FSI EFFECTS (NEGLIGIBLE) PRESENT IN A & B WILL ALSO BE PRESENT IN MARK II & III. (SEE FIGURE 12)

FREQUENCY DEPENDENCE

QUESTION 7: TO WHAT EXTENT IS THE DISTRIBUTION PLANT - SPECIFIC OR SRV - SPECIFIC? DOES IT DEPEND ON LINE LENGTH? LINE TEMPERATURE? FIRST OR SUBSEQUENT ACTUATION?

RESPONSE:

- DESIGN DISTRIBUTION VARIES WITH LINE VOLUME ONLY
- DISTRIBUTION IS BROAD ENOUGH TO ACCOUNT FOR ALL OTHER VARIABLES
- MARK II AND III PLANTS HAVE SAME BASIC GEOMETRY AS FAR AS SRV LOADS ARE CONCERNED. THIER FREQUENCY IS NOT EXPECTED TO VARY DUE TO PLANT GEOMETRY
- FREQUENCY IS A FUNCTION OF LINE VOLUME
- LINE TEMPERATURE EFFECT IS IMPLICIT IN THE DATA BASE
- CAORSO SECOND ACTUATION FREQUENCY HIGHER THAN FIRST ACTUATION. EARLIER TEST SHOWED THAT FREQUENCY DOES NOT DEPEND ON FIRST OR SUBSEQUENT ACTUATION

755 220

QUESTION 8: WHAT ARE THE DATA BASES FOR THE PROBABILITY DISTRIBUTIONS OF VALVE SETPOINT AND VALVE OPENING TIME?

RESPONSE:

VALVE SETPOINT

- FOR TESTABLE INSTRUMENTATION, SD - 2 PSI APPLIED TO BOTH CROSBY & DIKKERS VALVES
- FOR NON-TESTABLE INSTRUMENTATION SD = 8 PSI IS USED BASED ON 24 SHOP TESTS
- FOR TARGET ROCK VALVES SD - 5.9 PSI BASED ON 77 SHOP TESTS. FIGURE 13 SHOWS THE DISTRIBUTION IS CLOSE TO NORMAL.

VALVE OPENING TIME

- FOR CROSBY VALVES SD = .0092 SEC BASED ON 408 TESTS
- FOR DIKKERS VALVES D = .0097 BASED ON 50 TESTS. THEREFORE, STANDARD DEVIATION FOR BOTH CROSBY AND DIKKERS IS SPECIFIED AS 0.009 SEC.
- FOR TARGET ROCK VALVES 187 DATA POINTS GAVE SD = .013 SECONDS

755 221

AIR VOLUME ON FREQUENCY

QUESTION 9: IT IS PROPOSED THAT THE QBF DISTRIBUTION BE SHIFTED TO ACCOUNT FOR SRV LINE VOLUMES THAT DIFFER FROM THE 50 FT^3 LINES USED TO OBTAIN THE DATA. THE PROPOSED ADJUSTMENT IS BASED ON A SIMPLISTIC AND POSSIBLY NON-CONSERVATIVE ANALYSIS WHICH NEGLECTS THE KNOWN DEPENDENCE OF BUBBLE PRESSURE ON AIR LINE VOLUME. A REASSESSMENT OF THIS ASSUMPTION IS REQUIRED.

RESPONSE:

THE RELATIONSHIP GOVERNING FREQUENCY AND AIR VOLUME IS, FROM RAYLEIGH'S EQUATION

$$\text{FREQUENCY} \propto \sqrt[-3]{\text{AIR VOLUME}}$$

THE ENTIRE RELATIONSHIP HAS BEEN EXPERIMENTALLY CONFIRMED IN 1/4-SCALE T-QUENCHER TESTS FOR LINE VOLUMES RANGING FROM 24 FT^3 TO 99 FT^3 (SEE FIGURE 14)

755 222

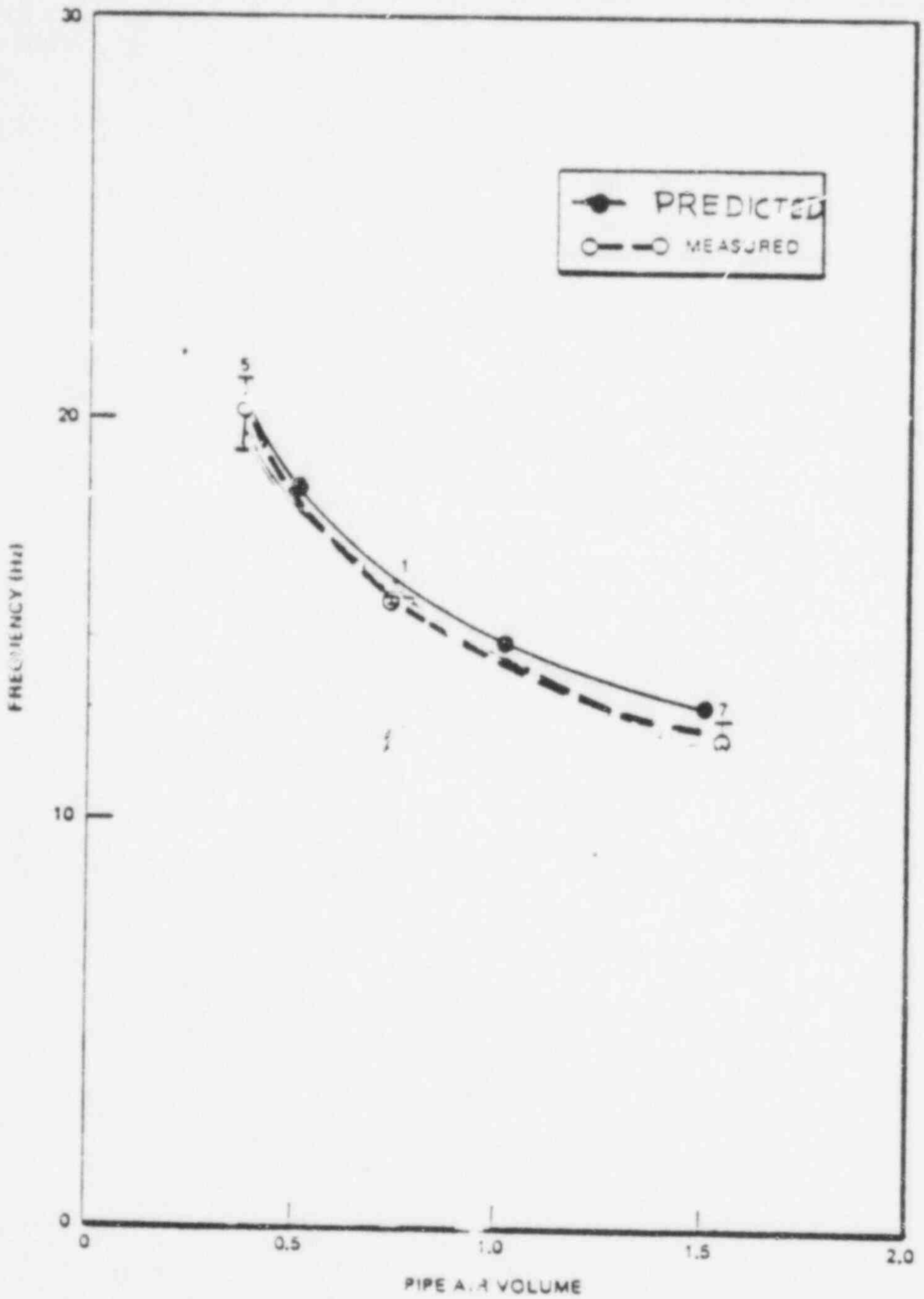

Figure 14 . Effect of Pipe Air Volume on Frequency for Initial Pipe and Wetwell Pressure of 3.7 psia

755 223

QUESTION 10: ONE CENTRAL ASSUMPTION OF THE PROPOSED METHODOLGY IS THAT BUBBLES OSCILLATING SIMULTANEOUSLY IN THE POOL DO NOT INTERACT IN ANY WAY THAT WOULD TEND TO INCREASE THE LOAD AMPLITUDES TO MODIFY THE PHASE DIFFERENCE BETWEEN THE BUBBLE OSCILLATIONS OR TO HARMONIZE THE OSCILLATION FREQUENCIES. THE BASIS FOR THIS ASSUMPTION IS ONE OF OUR MAIN PRESENT CONCERNS.

RESPONSE:

- o THEORY PREDICTS LITTLE INTERACTION
  - QUENCHERS ARE 14 FEET APART
  - BUBBLE DIAMETERS ARE 2.7 FEET
  - MEAN SPACING IS 5 DIAMETERS
  - EFFECT (1/R) IS 10%

- o TESTS SHOW NO INTERACTION
  - MONTICELLO TESTS SHOW SVA SHELL PRESSURES GENERALLY LESS THAN MVA SHELL PRESSURES
  - CAORSO 2 AND 3 VALVE MVA PRESSURES LESS THAN SVA PRESSURES
  - CAORSO 4 VALVE MVA PRESSURES ~20% HIGHER THAN SVA BUT WAVEFORM INDICATES NON-PHASED BUBBLES
  - CAORSO 8 VALVE MVA PRESSURES ~[illegible] [illegible]ER THAN SVA AND WAVEFORM INDICATES NON-PHASED BUBBLES

755 224

- MULTIPLE QUENCHER METHOD ALLOWS APPROXIMATE PHASING
  - EXAMPLE IN ATTACHMENT M
  - 3 BUBBLES AT 0.123 SEC AND 9.3 Hz
  - 2 BUBBLES AT 0.128 SEC AND 8.6 Hz

755 225

Valve No.	IVOT (sec)	Valve No.	IVOT (sec)	Valve No.	IVOT (sec)
1	0.067	7	0.067	13	0.056
2	0.069	8	0.051	14	0.061
3	0.065	9	0.062	15	0.056
4	0.059	10	0.065	16	0.065
5	0.063	11	0.058	17	0.057
6	0.038	12	0.057	18	0.071
				19	0.069

Note that a mean value of 0.057 sec is included in the above numbers. Adding these values to the group T_i calculated in Step 3 and normalizing to have the first bubble arrive at zero time results in the following bubble arrival times:

Valve No.	Arrival Time (sec)	Valve No.	Arrival Time (sec)	Valve No.	Arrival Time (sec)
1	0.125	7	0.125	13	0.243
2	0.256	8	0.238	* 14	0.127
3	0.123	9	0.120	15	0.243
4	0.247	10	0.0	16	0.124
5	0.122	11	0.246	17	0.245
6	0.225	12	0.116	* 18	0.129
				19	0.256

M.3 BUBBLE FREQUENCIES

Bubble frequencies for individual quenchers are randomly selected from a random number generator code using the distribution shown in Figure M2-4. Typical random bubble frequency values for the 19 quenchers are:

Valve No.	Frequency (Hz)	Valve No.	Frequency (Hz)
1	6.56	11	7.22
2	9.77	12	5.39
3	9.15	13	5.68
4	5.01	14	* 8.60
5	9.33	15	9.86
6	6.88	16	7.04
7	9.41	17	11.08
8	9.10	18	* 8.68
9	7.92	19	8.52
10	11.14		

NOTE: For this example, all lines are considered as uniform in length and frequencies are randomly selected from one Quencher Bubble Frequency (QBF) distribution curve (Figure M2-4). In this example, mean = 8.23 Hz and σ = 1.80 Hz. With nonuniform line lengths, Subsection M3.2.1 is used to develop unique QBF distribution curves from which a frequency is randomly selected for each line.

EFFECT OF LINE ON BUBBLE ARRIVAL TIME

QUESTION 11: AT PRESENT NO CREDIT IS TAKEN FOR POSSIBLE CHANGES IN BUBBLE ARRIVAL TIME DUE TO DIFFERENCES IN SRV LINE LENGTH OR HYDRAULIC RESISTANCE. THESE FACTORS COULD, HOWEVER, TEND TO NEGATE THE FAVORABLE EFFECT OF DIFFERENT VALUE SETPOINTS. THEY SHOULD BE ADDRESSED.

RESPONSE:

- o LINE AIR VOLUME AFFECTS BUBBLE ARRIVAL TIME SOMEWHAT BY CHANGING THE AIR AND WATER CLEARING TIMES
- o FOR EXAMPLE, AN INCREASE IN AIR VOLUME FROM 57 FT^3 TO 88 FT^3 CAUSES A DELAY OF 56 MSEC IN AIR CLEARING TIME
- o IN INDIVIDUAL PLANTS, AIR VOLUME USUALLY LIES WITHIN 25%
- o RESULT OF INCLUDING LINE VOLUME FOR A TYPICAL PLANT (57 FT^3 88 FT^3)
  - THE AVERAGE FOURIER SPECTRA REMAINED ESSENTIALLY UNCHANGED (FIGURES 15-20)

755 227

FORCING FUNCTION SELECTION

QUESTION 12: DISCUSS IN GREATER DETAIL HOW A FREQUENCY DEPENDENT "BOUNDING" FORCING FUNCTION IS DEDUCED FROM THE COMPUTED 59 MONTE CARLO SIMULATIONS.

RESPONSE:

- o THE FORCING FUNCTION IS BOUNDING IN THE SENSE THAT 59 TRIALS GIVE 95% CONFIDENCE THAT THE PEAK BOUNDS 95% OF ALL EXPECTED RESULTS. FEWER TRIALS WILL GIVE LESS CONFIDENCE

- o SIGNIFICANT FREQUENCY RANGE IS DIVIDED INTO 3 FREQUENCY AND LARGEST SPECTRAL VALUE WITHIN EACH FREQUENCY INTERVAL IS SELECTED FOR DETERMINATION OF EQUIPMENT RESPONSE

- o ADDITIONAL CONFIDENCE IN THE BOUNDING CHARACTERISTIC OF THE FORCING FUNCTION IS PROVIDED BY:

  - HIGHEST BUBBLE PRESSURE GIVEN BY ANY DISCHARGE LINE IS USED FOR ALL DISCHARGE LINES. THE MAXIMUM DESIGN BUBBLE IS EXTREMELY CONSERVATIVE. THE PREDICTED BUBBLE PRESSURE FOR CAORSO SVA IS 15.1/-8.9 PSI AS COMPARED TO MEASURED MAXIMUM PEAK BUBBLE PRESSURE OF 5.0/-4.5 PSI.

  - THE DISTANCE ATTENUATION OF GESSAR/DFFR BOUNDS CAORSO DISTANCE ATTENUATION

755 228

- GESSAR/DFFR TIME ATTENUATION BOUNDS TIME ATTENUATION OBSERVED AT CAORSO (SEE FIGURE 21)

- o FIGURE 21 ALSO SHOWS THAT CAORSO DATA IS BOUNDED BY PREDICTIONS BY A LARGE MARGIN
- o FOR LINEAR SYSTEMS, HIGHEST INPUT FOR EACH FREQUENCY GIVES HIGHEST OUTPUT

755 229

CONFIRMATORY WORK

QUESTION 13: IT IS OUR OPINION THAT COMPARISONS BETWEEN PREDICTIONS BASED ON THIS METHODOLGY AND MVA IN-PLANT LOAD DATA ALREADY AVAILABLE AND TO BE OBTAINED FROM THE CAORSO TESTS IS AN ESSENTIAL PART OF THE REVIEW PROCESS. BOUNDING FORCING FUNCTION PREDICTIONS FOR DISCHARGE CONDITIONS CORRESPONDING PRECISELY TO THOSE ACTUALLY TESTED (TWO, THREE, FOUR AND EIGHT VALVE DISCHARGES AT CAORSO, ALL MULTIPLE VALVE TESTS AT BRUNSBUTTEL) SHOULD BE GENERATED AND COMPARED WITH THE IN-PLANT LOAD DATA. IT IS RECOGNIZED THAT THE IN-PLANT DATA CONSISTS OF DISCRETE PRESSURE MEASUREMENTS A BEST ESTIMATE OF THE INTEGRATED LOAD MUST NEVERTHELESS BE OBTAINED.

WE EMPHASIZE THE NEED FOR COMPARISONS BETWEEN TEST DATA AND PREDICTIONS BASED ON THE PROBALISTIC PROCEDURE AS APPLIED TO DISCHARGE CONDITIONS IDENTICAL TO THOSE TESTED.

RESPONSE:

- A QUICK LOOK INDICATES THAT CAORSO MVA DATA IS BOUNDED BY PREDICTIONS BY A LARGE MARGIN
- MODEL/DATA COMPARISON UNDERWAY

755 230